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Document Subject:

TRANSMITTAL OF TRENCH 1 WASTE CHARACTERIZATION AND DISPOSITION PATHWAY'S ANALYSIS REPORT - JEL-006-99

KH-00003NS1A January 15, 1999

Discussion and/or Comments:

Enclosed are eight (8) copies of the Trench 1 (T-1) ***"Waste Characterization and Disposition Pathway's Analysis Report"*** for transmittal to the Department of Energy (DOE), RFFO (4 copies). This report is submitted in fulfillment of a Comprehensive Performance Measure Milestone deliverable to the Department of Energy (DOE) (4 copies) for a report describing the path forward for wastes excavated from Trench 1 during FY98. This report documents the characterization data for the T-1 waste and presents the plan for treatment and disposal of the various waste streams. The plan identifies existing treatment and disposal options applicable to T-1 waste and, where acceptable treatment and disposal options are not available, the document describes the plan to develop acceptable alternatives. The remaining 4 copies of the document are for Kaiser-Hill distribution.

Please contact Bob Griffis at extension 4934 if you have any questions regarding this matter.

Enclosures:
As Stated

cc:
A. C. Crawford w/o
M. C. Burmeister
T. Greengard
A. W. Horne
V. P. Valencia-Beckman w/o
RMRS Records
Administrative Record

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Trench 1 Characterization and Disposition Pathways Analysis Report

Rocky Mountain Remediation Services, L.L.C.
and
Kaiser-Hill, L.L.C.
Rocky Flats Environmental Technology Site
Golden, Colorado

January 15, 1999
Revision 0

EXECUTIVE SUMMARY

The remediation of Trench 1 (T-1) at the Rocky Flats Environmental Technology Site (RFETS) was conducted in accordance with the Proposed Action Memorandum (PAM) for the Source Removal at Trench 1 (RMRS, 1998a). Excavation of the trench was performed during the period June through August 1998. Several waste streams were generated from the source removal including radioactive metal wastes, contaminated soils, decanted lathe coolant, debris, and cemented cyanide waste. All wastes have been safely containerized and are currently stored within a Temporary Unit at the T-1 Site.

This report details the characterization of the radioactive metal wastes, contaminated soil, and other wastes generated during the remediation effort. It also discusses the treatment alternatives evaluated, and based on the evaluations, identifies the path forward for dispositioning each of the T-1 waste streams. This information is summarized as follows:

Waste Stream	Characterization	Proposed Disposition
I. Direct Disposal		
DU Ingot and PPE	LLW	Nevada Test Site
Soils <LDR	LLW/RCRA/TSCA	Envirocare
Debris	LLW/RCRA/TSCA	Envirocare
II. Treatment and Disposal		
Decanted Lathe Coolant		
Aqueous Liquid	LLW/RCRA/TSCA	RFETS CWTF
Organic Liquid	LLW/RCRA/TSCA	Offsite Treatment
Cemented Cyanide Waste	LLW/RCRA/ACM	Offsite Treatment
Radioactive Metals and Soil > LDR	LLW/RCRA/TSCA	Offsite Treatment

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CWTF Consolidated Water Treatment Facility
LLW Low Level Waste
RCRA Resource Conservation and Recovery Act
TSCA Toxic Substances Control Act

The first three waste streams listed in the above table (i.e., the depleted uranium [DU] ingot, used personal protective equipment [PPE], and soil) meet Land Disposal Restrictions (LDRs) and will be disposed at either the Nevada Test Site (NTS) or Envirocare as LLW and LLW/RCRA/TSCA mixed waste.

The last three waste streams listed in the table (i.e., lathe coolant, cemented cyanide, radioactive metal and soil wastes) do not meet LDRs and must be treated. The aqueous- phase lathe coolant is the only waste that is able to be treated at RFETS and will be treated at the Consolidated Water Treatment Facility (CWTF).

Several offsite and onsite alternatives were examined for the remainder of the non-LDR-compliant mixed wastes. Offsite treatment at both commercial facilities and several mixed waste treatment facilities currently operated within the DOE Complex was evaluated. The DOE facilities included the TSCA Incinerator at Oak Ridge National Laboratory (ORNL), the M-Area Vitrification Plant at Savannah River Plant (SRP), and the Waste Experimental Reduction Facility (WERF) at the Idaho National Engineering Laboratory (INEL). The commercial offsite facilities evaluated include:

- Materials and Energy Corporation (M&EC) in Oak Ridge, Tennessee;
- Allied Technical Group (ATG) in Richland, Washington;
- Perma-Fix Environmental Services in Gainesville, Florida;
- Diversified Scientific Services, Inc. (DSSI) in Kingston, Tennessee;
- Starmet Corporation in Barnwell, South Carolina;
- Envirocare of Utah, in Clive Utah; and
- Waste Control Specialists (WCS) in Andrew, Texas.

None of the seven commercial facilities listed above currently possess all of the necessary permits and licenses to treat the T-1 radioactive metal, soil, and cemented cyanide wastes. Two facilities, Perma-Fix and WCS, appear to be within six months away from obtaining the required permits and license modifications to treat the cemented cyanide waste. All seven of the commercial facilities identified could likely treat the cyanide waste under the RCRA treatability study exemption. A thorough evaluation will be completed to select the most appropriate commercial facility to treat the cyanide wastes. Barring any unforeseen circumstance, offsite shipment of these wastes will be completed prior to the end of Fiscal Year 1999.

Four of the commercial facilities listed above are currently working toward regulatory approval that will allow treatment of the T-1 radioactive metal and soil wastes. It is estimated that each of these facilities is currently 12-24 months away from receiving authorization to treat RCRA/LLW/TSCA wastes. However, four of the facilities, ATG, WCS, M&EC, and Perma-Fix are presently permitted or will be permitted this Fiscal Year for the storage of the radioactive metal and soil wastes. A thorough evaluation will be completed to select the most appropriate commercial facility for interim storage and future treatment of the radioactive metal and soil wastes. A contractual arrangement with a commercial facility for storage and future treatment and disposal of the wastes will be pursued this fiscal year, barring any unforeseen circumstances.

Alternatives evaluated for the onsite treatment of the radioactive metal and soil wastes include a variety of technologies including steam reforming, dechlorination, stabilization, solvent extraction/direct chemical oxidation, thermal desorption and oxidation, and vitrification. The evaluations indicated that onsite treatment using batch vitrification or steam reforming is technically feasible, but was eliminated from consideration at this time because of Clean Air Act issues, treatability testing requirements, and the negative public perception associated with operating thermal processes.

Safe interim storage and future treatment and disposal at an approved and permitted offsite commercial facility is the best path forward for the radioactive metal and soil waste streams. A contractual arrangement with a commercial facility for storage and future treatment and disposal of the wastes will be pursued this fiscal year.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ATTACHMENTS

ACRONYMS

Ac	Actinium
Am	Americium
ACM	asbestos containing materials
AEC	Atomic Energy Commission
ATG	Allied Technology Group
CBD	Commerce Business Daily
CERCLA	Comprehensive Environmental Response Compensation Liability Act
CWTF	consolidated water treatment facility
DCO	direct chemical oxidation
DOE	Department of Energy
DSSI	Diversified Scientific Services, Inc.
DU	depleted uranium
EPA	Environmental Protection Agency
HASP	Health and Safety Plan
IDLH	immediately dangerous to life and health
INEL	Idaho National Engineering Laboratory
kg	killigram
LANL	Los Alamos National Laboratory
LDR(s)	land disposal restrictions
LLW	low-level waste
M&EC	Materials and Energy Corporation
mg	milligram
NTS	Nevada Test Site
ORNL	Oak Ridge National Laboratory
OVA	organic vapor analyzer
PAM	Proposed Action Memorandum
PCB	polychlorinated byphenyls
PCE	Tetrachloroethene
PPE	personal protective equipment
Pu	Plutonium
RCT(s)	Radiological Control Technicians
RCRA	Resource Conservation and Recovery Act
R&D	research & development
RFETS	Rocky Flats Environmental Technology Site
RMRS	Rocky Mountain Remediation Services, LLC
SAP	Sampling and Analysis Plan
SET	solvated electron technology
SRP	Savannah River Plant
TCE	Trichloroethene
TCLP	toxicity characteristic leaching procedure
TD	Thermal Desorption
TH	Thorium
TSCA	Toxic Substances Control Act

U	Uranium
VOCs	Volatile Organic Compounds
WCS	Waste Control Specialists
WERF	Waste Experimental Reduction Facility

1.0 INTRODUCTION

Drums of buried waste were recently excavated from Trench 1 at the Rocky Flats Environmental Technology Site (RFETS). This excavation was conducted in accordance with the Proposed Action Memorandum (PAM) for the Source Removal at Trench 1, IHSS 108 (RMRS, 1998a). Several waste streams were generated from this source removal activity including radioactive metal wastes, contaminated soils, decanted lathe coolant, debris, and cemented cyanide waste. These wastes have been safely containerized and are currently being stored on an interim basis at the Trench 1 project site.

This report evaluates the treatment and disposal alternatives that are currently available for each of the Trench 1 waste streams. Based on the evaluations, a "path forward" for the final disposition of each waste stream is identified. The report first presents a detailed characterization of the Trench 1 waste streams as well as the expected pathway for disposition (Section 2). Section 3 describes the search conducted to identify offsite treatment alternatives for the wastes that do not meet land disposal restrictions (LDRs) and must therefore be treated. The regulatory permit and license status of the offsite facilities is also presented in Section 3. The technical merit of the onsite treatment alternatives is examined in Section 4. Finally, Section 5 summarizes the best path forward to be pursued for disposition of the Trench 1 waste streams based on the information and analysis presented in this document.

2.0 WASTE STREAM CHARACTERIZATION AND DISPOSITION

This section details the characterization of the soils and other waste streams encountered during the excavation. These waste streams were managed in a manner consistent with Rocky Flats policies and procedures and the requirements established by the PAM (RMRS, 1998a). All waste being sent offsite for disposal will be considered CERCLA waste as the wastes were generated under a CERCLA response action, under the Rocky Flats Cleanup Agreement, and all but uncontaminated field trash is considered low level radioactive waste (LLW). Table 2-1 provides a summary of the T-1 Wastes. This table includes waste types, volumes generated, final and proposed disposition and references to supporting information.

The major waste streams include:

- Radioactive metals (depleted uranium and other uranium/thorium waste streams),
- Decanted lathe coolants,
- Cemented cyanide,
- Debris, and
- Contaminated soil.

2.1 Radioactive Metals

Most of the radioactive metals removed from T-1 were depleted uranium (DU). Project personnel determined the uranium type and the potential presence of transuranic isotopes using gamma spectroscopy, throughout the project. No waste streams containing enriched uranium or transuranic isotopes (other than at low, near detection level concentrations) were detected during the T-1 project. The following subsections address both the radiological and chemical characterization of the radioactive metals.

2.1.1 Depleted Uranium

The main DU waste stream has been packaged in 154 containers, both overpack drums and B-12 waste packages as indicated by Table 2-1. The overpacks consist of 30- and 55-gallon drums recovered by the excavation overpacked into new 55-, 83/85-, and 110-gallon overpack drums as appropriate. The B-12 waste boxes are steel "half crates" with a volume capacity of approximately 1.6 cubic yards.

Characterization data collected during the excavation phase indicated that there was widespread contamination of the DU with chlorinated volatile organic compounds (VOC), polychlorinated byphenyls (PCBs), and cadmium. The primary chlorinated VOCs were tetrachloroethene (PCE) and trichloroethene (TCE), and the PCB was Aroclor-1254.

Extreme variability in chlorinated VOC, PCB and cadmium concentrations in DU samples has major waste management and disposal consequences. It seems reasonable to assume that much of the variability of the organic contaminants is attributable to the amount of "oil residue" that was present in some of the DU material being sampled, and that the amount of residue may be variable within an individual drum. Therefore, it would be difficult to accurately determine VOC and PCB concentration levels in an individual drum based on one sample from that drum. Therefore, the DU waste stream will be characterized as a lot, not on an individual drum-by-drum basis. Moreover, the sampling strategy developed to support the characterization of the DU was based on field segregation of material by physical characteristics or distinct geographic locations, if possible, within the trench (Starmet, 1998). Efforts focused on characterization by lot within the DU waste stream. The Sampling and Analysis Plan was not intended to address full characterization of individual drums or waste packages. Differences in physical characteristics and geographic locations that would have allowed segregation of individual drums were not apparent during excavation. Since not all drums were sampled for all possible constituents and breakout of DU using field segregation was not possible, breakout of DU by an identifiable lot was not possible.

The DU waste stream is considered contaminated with chlorinated volatile organic compounds that are typically considered F001 and F002 solvents (i.e., RCRA F-Listed chlorinated organic solvents) based on historic use at Rocky Flats. In addition, the waste code D006 (i.e., exceeds RCRA TCLP threshold for cadmium) has been applied because approximately 20% of the drums sampled exceed the TCLP thresholds for cadmium. Finally, the waste is considered a bulk PCB remediation waste under the Toxic Substances Control Act (TSCA).

There is one exception to the overall DU chemical characterization. A DU ingot or "puck" was uncovered during the excavation. This material was solid and did not appear to have been machined. This material was placed in a 55-gallon drum (D93471), inerted or packed with clean soil and subsequently overpacked into a 83-gallon drum (X10906). The volume of the DU puck is < 0.5 ft^3. This material was not sampled because the material was positively identified by one of the project RCTs familiar with the process of generating DU ingots or "pucks", and that sampling solid DU was not practicle with the sampling tools available. Because of its massive nature this waste is not considered pyrophoric and because it has not been machined (i.e., product stock) contamination is unlikely. Also cadmium presence is unlikely as the ingot was not a finished product and did not appear to have been plated - a probable source of the cadmium contamination. The ingot is considered low level radioactive waste and source material under the Atomic Energy Act.

2.1.2 Thorium

Through the use of gamma spectroscopy it was determined that some of the radioactive material removed from T-1 was not DU or DU contaminated. Two samples (a regular and duplicate) used to characterize a drum of radioactive material placed into an 83-gallon overpack indicated that the drum was contaminated by Thorium-232 (Th-232) through identification of its daughter products including Actinium-228 (Ac-228). Considering that the material is approximately 40 years old, the activity detected for Actinium-228 would approximate that of the Th-232 parent material. This would be approximately 20,000 pCi/g Th-232 for the material in the drum. The relationship between Ac-228 and Th-232 was confirmed using the computer software RADDECAY (Grove Engineering, 1987).

A B-12 waste box (number X09823) also contains Th-232 waste and unlike the drum described above contains DU as well. The in-process checklist used during the box filling indicates that the B-12 probably contains the contents of two non-intact drums and soil. The sample log clearly indicates that two distinct materials made up the sample from the B-12 (Sample number 98A2105-040) and the results confirm both the presence of thorium and DU. As a result, it is reasonable to assume that the B-12 contains both a thorium (Th-232) and a DU waste stream.

The thorium waste is also contaminated with PCE, TCE and PCBs similar to that of the DU. Significant cadmium was not detected in the drum, but was not sampled for in the B-12. Since this information is absent but possible, it is assumed that the waste in the B-12 contains cadmium and will be coded as D006 as well.

2.1.3 Natural Uranium

One B-12 waste box (X09829) contains the contents of old sample bottles. The sample jars make up a very small proportion of the contents of the B-12, with the remaining volume containing soil. The sample jars contain both natural and what is assumed to be DU ("tuballoy"). Analytical samples indicated the presence of PCE, however no PCBs or cadmium above TCLP thresholds was detected. The tuballoy itself was not sampled, and therefore the absence of PCBs or cadmium cannot be eliminated. Therefore, the same chemical characterization used for the DU has been applied.

2.2 Decanted Lathe Coolants

What appeared to be lathe coolant was decanted from a number of intact drums removed from the trench. The lathe coolant was segregated in accordance with the Starmet Sampling and Analysis Plan (SAP) (Starmet, 1998). Two 55-gallon drums were filled with what appeared to be an aqueous phase liquid (X07938, X07927), while one drum (X07935) was filled with an organic phase liquid. Analytical results confirmed the presence of chlorinated VOCs and PCBs in the lathe coolant, while significant levels of inorganic contaminants (metals) were not detected. Because of the presence of PCE, TCE and PCBs, this waste stream is considered to be an F001, F002 hazardous waste and also a TSCA Remediation Waste.

In December 1998 the two drums containing aqueous phase liquids were transferred to the RFETS Consolidated Water Treatment Facility (CWTF) for treatment. The liquid in Drum X07935, which contained the organic top phase, will be treated along with the radioactive metal wastes and soils contaminated above LDR levels.

2.3 Cemented Cyanide

Ten 55-gallon drums of unsolidified cemented cyanide waste were exhumed from the trench. Several issues existed regarding the classification of this waste.

Samples were collected from each of the ten drums for gamma spectroscopy and total cyanide analysis. All results indicated low level uranium contamination and significant levels of cyanide (0.51 - 5.3 weight %). Most of the drums appeared to contain asbestos fibers; samples from two drums were analyzed for asbestos and both contained significant asbestos (15 and 25% by volume). Four samples were collected from three of the drums (this included one duplicate) and were analyzed for VOCs/SVOCs, the full TCLP list, reactive sulfide, reactive cyanide, corrosivity, and isotopic Pu, Am, U, as well as additional gamma spectroscopy. These four samples are representative of the entire waste stream. A summary of the analytical results follows:

- No VOCs or SVOCs were detected,
- All samples exceeded TCLP thresholds for cadmium (829-1,200 mg/L),
- No other TCLP thresholds were exceeded,
- pH was in the range of 12.4-13.2,
- Reactive Sulfide was undetected,
- Reactive Cyanide: Three of four samples reported as undetected. One sample reported as 0.3 mg/kg reactive cyanide.

As the PAM states, the original cyanide generation process could not be established with full confidence. As a result, it was originally planned to rely on the wastes characteristics to determine if it was hazardous waste or not. After a more thorough evaluation, the generation process was essentially determined to be a listed electroplating process. The applicable listings are F006 and F008 and are defined as "Wastewater treatment sludges from electroplating operations...", and "Plating bath residues from the bottom of plating baths from electroplating operations where cyanides are used in the process", respectively. Though there are no LDR implications, the waste code D006 is also being added to the cemented cyanides as the waste exceeds the TCLP standard for cadmium.

2.4 Debris

Other than drum carcasses, very little debris was encountered during the T-1 excavation. Deteriorated drum carcasses (fragments), drum lids and rings were typically removed as practical and visually verified free of chips or turnings so that they would be considered non-pyrophoric. This material was then placed in B-12 or B-88 type waste boxes. The B-88 waste boxes are steel "full crates" with a volume capacity of approximately 3.6 cubic yards. The other types of debris encountered included a few pieces of pipe, a small volume (<1ft^3) of some type of sandpaper and cardboard containers identified as "ice cream cartons" in the field. These cardboard containers were apparently used to hold DU floor sweepings from building 444. There were six B-88's and three B-12's filled with debris. Since very little debris was encountered, few samples were collected. Only one full chemical suite sample was collected, along with a few additional gamma spectroscopy samples. All samples showed evidence of DU contamination. The full suite sample was collected from the cardboard "ice cream cartons". The sample contained PCE at 23 ug/kg, (F001, F002 but below the current LDR levels), PCB (Aroclor-1254) at 730,000 ug/kg, and various RCRA metals including cadmium, all well below the TCLP thresholds. As such, the waste is considered an LDR compliant mixed hazardous waste with the following RCRA codes, F001 and F002. In addition, the waste is considered a mixed TSCA Remediation waste. Since much of the debris is rusty metal fragments, it may not be practical to use the RCRA debris standard to exit the RCRA hazardous waste regulations.

The sample of the cardboard "ice cream cartons" is probably a "worst case" sample as it contained DU, was very porous, and hence was able to absorb contaminants better than the typical metal drum fragment.

2.5 Soil

Soil not returned to T-1 was segregated using radiological and VOC field screening techniques into the categories described in Section 3.1. Analytical results from eleven B-88s containing soil with OVA reading at > 25 ppm contained chlorinated VOCs (primarily PCE and TCE) at concentrations up to 51 mg/kg, and Aroclor-1254 up to 16 mg/kg. As such, the waste is considered a non-LDR compliant mixed hazardous waste with the following RCRA codes: F001 and F002. In addition, the waste is considered a mixed TSCA Remediation waste. This material is considered one lot, and will require treatment prior to disposal, to address the F001 and F002 constituents.

Twelve gamma spectroscopy and four full suite chemical samples were collected from fifty-two B-88s containing soil with OVA reading at < 25 ppm. This waste stream was originally anticipated to be LLW, suitable for disposal at NTS. However, one sample from this lot of B-88s' contained a positive detection of PCE at 24 ug/kg, and Aroclor-1254 (a PCB) at 650 ug/kg. As such, the waste is considered an LDR compliant mixed hazardous waste with the following RCRA codes: F001 and F002. In addition, the waste is considered a mixed TSCA Remediation waste. This material is considered one lot, and will not require treatment prior to disposal.

3.0 IDENTIFICATION OF OFFSITE TREATMENT ALTERNATIVES

The original plan of treating the DU wastes and soils contaminated with significant levels of DU at the Starmet Corporation's reprocessing facility in South Carolina was eliminated from consideration based on the unanticipated presence of RCRA and TSCA components in these waste streams. Starmet's reprocessing facility does not currently possess the necessary permits to accept and treat RCRA- and/or TSCA-contaminated wastes. With this pathway eliminated, the feasibility of treating the Trench 1 wastes at offsite DOE and commercial facilities was examined. The results of these searches are presented below.

3.1 Offsite DOE Treatment Alternatives

The mixed waste treatment facilities currently operated within the DOE complex were evaluated with respect to the feasibility of treating Trench 1 wastes. The facilities considered include the TSCA Incinerator at Oak Ridge National Laboratory (ORNL), the M-Area Vitrification Plant at Savannah River Plant (SRP), and the Waste Experimental Reduction Facility (WERF) at the Idaho National Engineering Laboratory (INEL). Table 3-1 presents the regulatory permit and license status of these facilities as well as other information pertinent to the treatment of Trench 1 wastes.

The TSCA Incinerator at ORNL is not a viable option at this time because of a moratorium on the acceptance of out-of state wastes (other than from the DOE Portsmouth and Paducah facilities) imposed by the State of Tennessee. The time frame for the lifting of this moratorium is unknown. In addition, the processing capacity that is reserved at the facility for solid wastes is limited because of a large backlog of liquid wastes (preferred waste stream) to be treated at the facility. Under the facility's current Burn Plan, additional solid wastes are not expected to be considered for incineration until at least Fiscal Year 2000.

Table 3-1 indicates that the Trench 1 wastes radioactive metal and soil wastes do not meet the waste acceptance criteria of the M-Area Vitrification Plant because of the VOC levels present. The M-Area facility does not possess the necessary offgas treatment equipment to address the VOC levels in question. Table 3-1 also indicates that the WERF is not permitted to treat TSCA-regulated wastes.

A potential alternative to using one of the fixed DOE treatment facilities noted above is combining the Trench 1 wastes with a similar waste stream of another CERCLA project within the DOE Complex. Such a strategy may pose insurmountable regulatory and administrative challenges. Nonetheless, additional investigation of this strategy will be examined.

3.2 Offsite Commercial Treatment Alternatives

The possibility of treating the radioactive metal waste and contaminated soil at an offsite commercial facility was investigated. The search involved: contacting numerous commercial facilities regarding their treatment capabilities and regulatory permit status; conferring with DOE Mixed Waste Focus Area personnel at INEL regarding commercially-available treatment capabilities; reviewing research regarding the identification of treatment alternatives for a nearly identical DU waste stream at the Hanford facility; and finally, publishing a Commerce Business Daily (CBD) announcement (Appendix A) requesting technical and regulatory permit and license information pertinent to the treatment of the Trench 1 radioactive metal, contaminated soil, and cemented cyanide wastes. The CBD announcement encouraged responses regarding both offsite and onsite treatment alternatives, but emphasized a preference that the wastes be treated at an existing offsite facility.

The search described above identified six offsite commercial facilities: Materials and Energy Corporation (M&EC), Allied Technology Group (ATG) - Richland, Perma-Fix Environmental Services of Florida (Perma-Fix), Diversified Scientific Services, Inc. (DSSI), Starmet Corporation, and Waste Control Specialists (WCS). The regulatory permit and license status of these facilities along with other information pertinent to the treatment of Trench 1 wastes is presented Table 3-2. This information is examined below first with respect to the treatment of the radioactive metal and soil wastes (i.e., low-level mixed waste including PCBs), and second, with respect to the treatment of the cemented cyanide waste (i.e., low-level mixed waste without PCBs).

3.2.1 Radioactive Metal and Soil Wastes

In order for an offsite facility to treat the Trench 1 radioactive metal and soil wastes, it must have the capability and permits to treat a mixed waste (RCRA/LLW/TSCA/CERCLA) as follows: all underlying hazardous constituents (both organic and inorganic) must be managed by either knowledge of the waste, or alternatively, treatment to LDRs required by 40 CFR 268. Knowledge of the wastes and analytical data indicate that a variety of chlorinated solvents, PCBs, and leachable cadmium must be reduced in their concentrations prior to landfill as a radioactive listed hazardous waste (F001, F002) meeting LDRs.

The information presented in Table 3-2 indicates that none of the six commercial facilities evaluated in the search for offsite alternatives are fully permitted and licensed at this time to treat the Trench 1 radioactive metal and soil wastes at this time. M&EC, for example, is not expected to have the requisite RCRA and TSCA permits in place for at least 12 months. In the case of ATG, managers expect their Richland facility to receive its RCRA/TSCA permit in 1999, however, the facility is limited by its radioactive materials license to receive only 10,000 kg of Atomic Energy Commission (AEC) source material. This constraint is far exceeded by the estimated 156 tons of Trench 1 radioactive metal and soil waste. In addition, permit-required demonstration testing of equipment that is to be installed in 1999 is not anticipated to be completed until the first quarter of 2000.

Table 3-2 indicates that Perma-Fix is currently permitted under RCRA to store, blend, and repackage hazardous wastes. Perma-fix cannot currently treat hazardous waste. However, the company has applied for a modification to its RCRA Part B permit requesting approval to treat hazardous wastes as well. Approval is expected by the company in May 1999. The application is currently focused on a limited number of hazardous waste codes and hazardous constituents; Perma-Fix lacks test data describing performance of its proprietary in-house technology for all RCRA underlying hazardous constituents. Perma-fix has likewise submitted an application for the storage of TSCA wastes and anticipates regulatory approval for this request by mid 1999. The company has not yet submitted an application for the treatment of TSCA wastes, however. The company has recently applied for a TSCA RD&D permit for the experimental testing of PCB wastes. Data generated from the TSCA R&D permit will be used to support modification of the RCRA permit and preparation of a TSCA permit application. Although the TSCA RD&D permit does not impose a waste volume or mass limit, the proposed permit's stipulation that wastes treated under this permit must be disposed at pretreatment levels effectively eliminates its use for treating the radioactive metal and soil waste streams.

WCS currently holds a RCRA permit that allows solidification/stabilization and chemical oxidation of hazardous waste. The company has applied for a permit modification to allow treatment with other processes, such as thermal desorption and dechlorination, which are necessary for the treatment of the Trench 1 radioactive metal and soil wastes. The estimated time for review and approval of this permit modification is 12 to 18 months. WCS is permitted at this time, however, to store the radioactive metal and soil wastes at their Andrews, Texas facility.

DSSI operates a fully permitted and licensed industrial boiler for the treatment of low level mixed waste *liquids* including aqueous liquids, organic solvents and used oils. The company has recently applied for a permit modification for the treatment of solid wastes. Approval of this request is not expected for at least 12 months. DSSI's radioactive materials license allows for the treatment of wastes containing radioactive materials with atomic numbers 1 through 83, and transuranics (including various isotopes) with atomic numbers 88, 90, and 92 through 96 and with an annual processing limit of over 20,000 curies. DSSI does not possess a TSCA permit, however, and liquid wastes processed at their industrial boiler facility must therefore contain less than 50 ppm PCBs.

Envirocare of Utah, Inc. (Envirocare) carries permits to handle both LLW and RCRA wastes. However, Envirocare lacks permit capacity and treatment expertise for reducing PCBs in this material to meet LDRs associated with the Trench 1 radioactive metal and soil wastes. As noted in the introduction to this section, Starmet does not currently possess a RCRA or TSCA permit.

3.2.2 Cemented Cyanide Waste

In order for an offsite facility to treat the Trench 1 cemented cyanide wastes, it must have the capability and permits to treat a mixed waste (RCRA/LLW/CERCLA) as follows: the specific hazardous constituents underlying the F008 waste codes must be treated to meet the 40 CFR 268 LDR standards. In particular, leachable cadmium and total cyanide must be reduced to LDRs prior to landfill. The treatment must be capable of handling Asbestos Containing Materials (ACM). The residues can then be landfilled as radioactive, ACM, F006 hazardous wastes meeting LDRs.

However, management of this material must respect their rather unique and complex nature. Certainly, the combination of regulatory umbrellas (RCRA/LLW/CERCLA/Asbestos), waste chemistry (i.e., elevated cyanide, leachable cadmium, and asbestos), and heterogeneity make this waste, at least, unusual.

As is the case for the radioactive metal and soil wastes, none of the six offsite facilities listed in Table 3-2 are fully permitted and licensed to treat the cemented cyanide wastes at this time. However, the information presented in Table 3-2 indicates that Perma-Fix and WCS will become fully permitted in this regard in approximately three to four months. Perma-Fix must gain approval of their RCRA permit modification request to treat hazardous waste. As noted above, approval of this request is expected by May 1999. Alternatively, Perma-Fix is able to treat the cemented cyanide waste at this time under the RCRA Treatability Exclusion. The approximately 4,000 kg of Trench 1 cyanide waste is less the 10,000 kg limit allowed under the exclusion. It should also be noted that Perma-Fix has been issued CERCLA Offsite Authorization by the EPA as indicated in Table 3-2.

It is anticipated that WCS will also be fully permitted to treat the cyanide waste in approximately three months. Although the company currently possesses a RCRA permit for chemical oxidation and stabilization/solidification (see below), their radioactive materials license must be amended to allow treatment of radioactive-contaminated wastes with these processes. This amendment has been submitted and is expected to be approved within two to three months. Unfortunately, use of the RCRA Treatability Exclusion to facilitate the treatment of the cyanide wastes is not an option at WCS. The State of Texas requires the aforementioned amendment to the facility's radioactive materials license to be approved for treatability work as well. Once this amendment is approved, however, the cyanide wastes may be treated at WCS under the DOE Broad Spectrum Contract (Bechtel, 1998). This contract is already in place and offers competitively bid pricing for the turnkey treatment and disposal of wastes. The cemented cyanide wastes would be treated and disposed as Treatment Category C wastes under the Broad Spectrum

Contract. Category C wastes include non-combustible, low level wastes that are coded F006 and F007 as well as codes requiring similar treatment. It should be noted that WCS has not yet been approved by RFETS to receive wastes. Kaiser-Hill evaluation of the WCS facility is scheduled for February 1999.

The technologies proposed by Perma-Fix and WCS to treat the cyanide wastes are similar and involve the use of chemical oxidation to reduce total cyanide levels below 590 mg/kg followed by cementation to stabilize the cadmium. Both companies indicate the need to conduct treatability tests with samples of the cemented cyanide waste in order to formulate the proper oxidation and stabilization "recipes." Treatability testing is particularly important considering the strong cyanide complexes that appear to exist in the waste suggested by the relatively low amenable (i.e., reactive) cyanide analytical data. Also, TCLP values approximately 10,000 times the LDR limit for cadmium (see Section 2) pose a challenge for treatment and warrant treatability testing as well.

As noted above, treatment under the RCRA Treatability Exclusion is limited to 10,000 kg of waste for their treatability study. Review of both 40 CFR 261 and 40 CFR 268, as well as conversations with the USEPA Hotline, indicate that if the heterogeneity of the cemented cyanide waste dictates a treatability mass up to 10,000 kg, then treatability study success (where LDRs for both cadmium and total cyanide are met) would allow landfill at a RCRA regulated Subtitle C facility, with notification that LDRs are not exceeded, without further treatment in a RCRA regulated or specifically exempted Treatment Unit. If a receiving facility can reliably test treatment of this unique and complex waste with a mass significantly less than 10,000 kg, then a successful treatability study thus leads to 1) landfill at a RCRA Subtitle C facility for treatability study residues and 2) treatment to LDRs and landfill at a RCRA Subtitle C facility for any remaining cemented cyanide waste.

Table 3-2 indicates that M&EC, ATG, DSSI, Starmet, and Envirocare could also employ the RCRA Treatability Exclusion to process the cemented cyanide waste. However, M&EC, DSSI, and Envirocare do not currently possess the necessary process equipment and ATG has expressed a preference not to conduct work under the Treatability Exclusion while their RCRA/TSCA permit application is being reviewed by the regulatory agencies. Starmet's business involves the recycling of DU and the fabrication of metal components. The firm is not interested in processing the cemented cyanide wastes.

4.0 ONSITE TREATMENT OF RADIOACTIVE METAL WASTES AND CONTAMINATED SOIL

The analysis presented in the previous section indicates that it may be one to two years before the Trench 1 radioactive metal and soil wastes can be treated at an offsite commercial facility. This lead time, as well as the uncertainty associated with it, necessitates an examination of onsite treatment alternatives. The discussion presented in this section therefore considers alternatives for the onsite treatment of the radioactive metal and soil wastes. Onsite treatment of the cemented cyanide waste is not considered because a pathway exists for the offsite treatment of these wastes by the end of the current fiscal year (Section 3).

The search for different options to treat Trench 1 wastes identified six onsite treatment alternatives. The vendors offering an onsite treatment alternative along with the treatment technologies included in the alternatives are summarized below.

Respondent	Technologies included in Onsite Treatment Alternative
GTS Duratek	Steam Reforming, Solvated Electron Dechlorination Technology, and Stabilization.
Materials and Energy Corporation	Solvent Extraction/Direct Chemical Oxidation, Thermal Desorption, and Stabilization.
Geosafe Corporation	Batch Vitrification.
ATG	Continuous Plasma Arc Vitrification.
Perma-Fix	Thermal Desorption, Direct Chemical Oxidation, and Stabilization.
Starmet	Solvated Electron Dechlorination Technology, and Thermal Oxidation

Detailed descriptions and evaluations of each of these onsite treatment alternatives are presented in Appendix B. The evaluations focus on the expected effectiveness in achieving regulatory-driven treatment goals as well as the challenges associated with implementing the alternative at RFETS. Brief summaries of the treatment alternative evaluations are presented below.

4.1 GTS Duratek

GTS Duratek proposes that the radioactive metal and soil wastes be treated with a combination of solvated electron technology (SET) and steam reforming technology as illustrated by the process flowsheet presented in Figure 1. Following treatment by these processes, the wastes are then stabilized by cementation to eliminate the toxicity characteristic associated with the leachability of cadmium.
SET technology employs a liquid reagent to dechlorinate the organic solvents and PCBs present in the wastes, rendering them as non-hazardous hydrocarbons. The chlorine present in the organic contaminants is displaced by hydrogen and forms either sodium or calcium chloride depending on the reagent used. Steam reforming technology volatilizes organic contaminants (i.e., chlorinated solvents and PCBs) from the solid waste matrix and destroys them by reaction with superheated steam. Because the degradation reactions occur in an oxygen-depleted environment (i.e., steam displaces air in the unit), the organics are reduced to simple gases without the problems associated with thermal oxidation (i.e., incineration). Steam reforming technology has the added benefit of eliminating the pyrophoric characteristic of the DU. Metallic uranium is irreversibly converted into uranium oxide (Waber, 1956).

Both steam reforming (Gibson, 1997) and SET (Commodore, 1998) have been found to be effective in reducing the concentrations of chlorinated solvents and PCBs required to meet LDRs. The crushing and screening operations performed prior to treatment (Figure 1) aid treatment by increasing the solid waste surface area available for contact with the reagent (i.e., SET solution or superheated steam). Such feed preparation activities have three important disadvantages: worker exposure, equipment shutdown, and equipment decontamination. The potential for exposing workers to contamination is significant considering the need to transfer the wastes from the drums to the feedstock preparation equipment and from treatment unit to treatment unit.

Even with the feed preparation operations described in Figure 1, it remains uncertain that the degree of solid-reagent contact necessary for effective treatment will be achieved in the SET unit when processing oily DU sludges and thorium pastes. "Channeling" may occur in these wastes which will serve to limit the surface area of the solid waste exposed to the liquid reagent. With respect to steam reforming, the need to remove the wastes from the container and size reduce them may or may not be necessary. Entire drums of waste have been successfully treated by steam reforming without first having to remove and prepare the waste. In these cases, the superheated steam effectively penetrated the solid wastes to desorb the organic contaminants. The degree of steam penetration depends on the physical and chemical nature of the waste and can only be verified through waste-specific treatability testing.

The reader is referred to Appendix B for a more in depth discussion of the materials handling issues associated with the treatment alternative suggested by GTS Duratek.

4.2 Materials & Energy Corporation (M&EC)

M&EC suggests that the radioactive metal and soil wastes be treated by solvent washing and vacuum-enhanced thermal desorption (TD), as illustrated by the flowsheet presented in Figure 2. As in the GTS Duratek process, the mineral oil is drained and the wastes segregated prior to treatment. Waste liquids and sludge recovered during oil draining, solvent washing, and TD operations are treated by direct chemical oxidation (DCO), and the waste from the DCO unit is stabilized for land disposal. Containers are decontaminated with a non-hazardous solvent and the spent solvent is recycled to the solvent washing unit.

The primary advantages of solvent washing are its simplicity, room temperature operation, and relatively high contaminant removal efficiencies for certain types of wastes such as granular solids and sands containing organic surface contamination. The effectiveness of solvent washing the Trench 1 oily sludges and pastes is uncertain, however. Particle size and porosity of the waste solids as well as any surface coatings and channeling may limit the solid-liquid contact achieved in the unit. The treatment approach suggested by M&EC addresses the need for solid-reagent contact (as well as solid-gas sweep contact in the TD unit) by sorting and size reducing the wastes prior to treatment. These feedstock preparation activities should enhance the overall waste-reagent contact achieved in both the solvent washer and the TD unit, but as discussed in Section 4.1 for the GTS Duratek alternative, such feed preparation generate worker exposure, equipment shutdown, and equipment decontamination concerns. Entrainment of solids during solid-liquid separation, safety hazards associated with using solvents with pyrophoric material, and the generation of secondary waste streams (i.e., spent solvent and filter media) pose operational challenges with this technology as well.

There is an abundance of data demonstrating the performance of TD technology for removing chlorinated solvents. In fact, the TD unit proposed by M&EC has been successfully used three times at RFETS for desorbing TCE and PCE from soils (i.e., Ryan's Pit, Mound Site, and the Trench T-3/T-4 projects). TD technology has also been shown to be effective in the removal of heavier organic contaminants such as PCBs (i.e., less than 2 ppm) when high vacuums are applied (Mclaren Hart, 1998). The pyrophoric nature of DU and the presence of PCBs in the wastes necessitates the use of an inert gas sweep, however. The presence of oxygen and PCBs at elevated temperatures may potentially result in the formation of dioxin and furan compounds. Treatability testing must be conducted to ensure that these reactions do not occur. Also, oils not removed in the solvent washer are susceptible to smoking, where the nature of the radiant heat source can lead to high localized waste temperatures and subsequent cracking of any oils present.

4.3 Geosafe Corporation

Geosafe Corporation proposes that the Trench 1 radioactive metal and soil wastes be treated in a batch vitrification unit. The primary components of the unit are illustrated in Figure 3 and include a waste treatment cell, an offgas collection hood, and an offgas treatment system. The bottom of the cell is "lined" with approximately three feet of compacted, clean soil. Drums and waste boxes containing the radioactive metal and soil wastes are placed on the soil liner in the center of the treatment cell. Soil is then used to fill the void spaces inside and between the containers. Clean soil is then placed around and over the top of the drums and compacted with a backhoe or excavator.

With the offgas treatment system is in place, electrical current is applied to the contents of the treatment cell. The current is converted to heat which melts the soil and wastes from top to bottom. The temperature of the melt typically ranges from 1,600 to 2,000°C. The temperatures achieved in the melt serve to pyrolize organic contaminants and debris present in the soils and wastes to simple gases (e.g., carbon dioxide, carbon monoxide, simple hydrocarbons, water vapor, and hydrochloric acid). The offgas leaving the collection hood is treated prior to atmospheric discharge. Inorganic contaminants are oxidized and are chemically incorporated in the melt. After all wastes are melted, as indicated by the electrodes reaching the soil liner, the power is de-energized and the melt allowed to cool and solidify (several days). The resulting glass-like product is chipped out of the treatment cell and containerized for subsequent disposal. The treatment cell is charged with the next batch and the process repeated.

The batch vitrification process proposed by Geosafe has several important advantages with respect to the treatment of Trench 1 radioactive metal and soil wastes. First and foremost is the minimal amount of feed preparation and worker handling that is required. The process does not require that wastes be removed from their containers. The steel drums and waste boxes are melted along with the wastes in the treatment cell. The reader is referred to Appendix B for a detailed discussion regarding specific activities associated with loading the treatment cell.

As is the case with steam reforming and SET, vitrification has the benefit of eliminating regulated organic contaminants in one step. In addition, vitrification has the benefit of stabilizing radionuclides and hazardous metals in this same step. The need to transfer the wastes to a cementation unit, for example, is eliminated. Stabilization is achieved by chemically incorporating the metals into the glass product. Additional information concerning melt chemistry and the incorporation of inorganic contaminants in the melt is presented in Appendix B.

Bench-scale vitrification data indicate that as much as 99.99% of the uranium present in the feedstock wastes is retained in the final glass product (Hansen, 1991). Similar studies have indicated retention efficiencies as high as 99.99% for thorium as well (Hansen, 1991). Unfortunately, bench- and pilot-scale studies suggest only a 67 to 75% retention efficiency for cadmium, a semi-volatile metal. A commonly cited drawback of vitrification technology is the potential for hot gases generated in the melt to accumulate in void spaces present within the treatment cell. If the space is large enough and sufficiently confined, violent release of accumulated vapor can occur in the melt. This phenomenon is of particular concern when attempting in place or *in situ* vitrification of buried wastes (i.e. In this case, it is difficult to know where void spaces may exist in the subsurface or within buried containers. In contrast, there is much more control and certainty in batch or *ex situ* applications of this technology. Void spaces can be filled and compacted while charging the treatment cell.

Appendix B provides additional discussion on the advantages and disadvantages associated with batch vitrification of Trench 1 wastes.

4.4 Allied Technology Group (ATG)

ATG proposes that the Trench 1 radioactive metal and soil wastes be treated in a continuous vitrification unit. As illustrated in Figure 4, electric power is delivered to the treatment unit in two forms. The first is an alternating current, similar to that employed in the Geosafe batch vitrification process, that is applied to the melt at the bottom of the unit. A second source of power, a high energy direct current, is applied in the vapor space directly over the surface of the melt. The resulting electric arc creates an extremely high temperature plasma (approximately 12,000°C).

In practice, waste is continuously fed into the treatment chamber with an auger. The feed is directed through the plasma and into the melt. Pyrolysis of organic contaminants occurs in both the melt and the plasma arc. The elevated temperatures of the plasma ensure that the pyrolytic reactions are taken to completion to form carbon dioxide and hydrogen. The offgas from the plasma arc unit is treated prior to atmospheric discharge in a similar manner as described earlier for the batch vitrification process. The melt continuously exits the treatment unit through an overflow weir. The molten flow is directed into waste containers where it is allowed to cool and solidify.

Many of the same assessments made in Section 4.3 for batch vitrification technology also apply to ATG's continuous plasma arc vitrification process. Both technologies offer the benefit of organic contaminant destruction and inorganic contaminant immobilization in one processing step. However, the continuous feed and processing requirements of the plasma arc process necessitates size reduction and blending of the wastes to ensure a successful operation. Such activities raise concerns of worker exposure and equipment downtime as discussed in other sections of this report regarding the technologies proposed by GTS Duratek, M&EC, and Perma-Fix. The ability to decontaminate the feed preparation equipment and feed auger for free release at the conclusion of the project is also uncertain. The risks associated with auger jamming and flow blockage must also be considered.

A more detailed evaluation of ATG's continuous plasma arc treatment technology is provided in Appendix B.

4.5 Perma-Fix Environmental Services

As with M&EC, Perma-Fix suggests that solvent washing and TD technologies be used to remove organic contaminants from the Trench 1 radioactive metal and soil wastes (Figure 5). Likewise, cementation is proposed to solidify wastes prior to disposal. Description and evaluation of these technologies for the treatment of Trench 1 wastes need not be repeated. The reader is referred to the discussion and analysis presented in Section 4.2 and Appendix B.

4.6 Starmet Corporation

The Starmet proposal includes a treatment strategy that is based on the incorrect position that individual containers of Trench 1 wastes can be "segregated" from a waste classification standpoint. The proposal assumes, for example, that a drum of DU waste can be considered nonhazardous if the one sample analysis for that drum was found to contain RCRA and TSCA contaminant concentrations less than land disposal restrictions. This is, of course, in contrast to the RCRA- and TSCA-regulated determinations presented in Section 2 which apply to the entire waste stream. With this said, the only regulatory-permissible alternative proposed by Starmet is a combination of onsite treatment with SET to eliminate chlorinated organic contaminants (see Section 4.1), followed by offsite treatment at a RCRA-permitted facility (i.e., Perma-Fix) to stabilize the wastes. The disadvantages and uncertainties associated with the use of SET for the treatment of Trench 1 wastes are discussed in Section 4.1. Moreover, the combination of onsite and offsite treatment is not economical and unnecessarily generates additional wastes. It makes far more sense to continue treatment through to its logical end once it is started as opposed to repacking SET-treated DU wastes with fresh mineral oil and shipping to an offsite location to complete treatment.

4.7 Preferred Onsite Treatment Alternatives

A comparative analysis of the onsite treatment alternative evaluations (Appendix B) suggest that two technologies, steam reforming and batch vitrification, have the most potential for successfully treating the Trench 1 radioactive metal and soil wastes. In summary, the distinguishing benefits of these technologies include minimal feed preparation and worker exposure and the destruction of organic contaminants in one processing step. Batch vitrification has the added advantage of immobilizing the inorganic contaminants into a superior waste form in this same processing step. However, there are uncertainties associated with the application of each of these treatment technologies to the Trench 1 wastes. In the case of steam reforming, for example, there is uncertainty regarding the ability of the steam to effectively penetrate the various solid waste forms without first size reducing and segregating the feedstock. Uncertainties regarding batch vitrification include hazards associated with void spaces present in the wastes, vaporization of semi-volatile metals, and formation of dioxin and furan compounds resulting from the partial oxidation of PCBs in the feedstock.

Using batch vitrification as a proxy, the implementation of an onsite treatment alternative is estimated to cost approximately two million dollars and require approximately 15 to 18 months to complete (see Appendix B).

5.0 SUMMARY OF TREATMENT AND DISPOSAL STRATEGY

5.1 DU Ingot, PPE, and Contaminated Soils (<LDR)

Many of the Trench 1 waste streams meet LDRs and will be land disposed at either NTS or Envirocare. The wastes that will be sent to NTS include the DU ingot (one drum) and the waste PPE generated during trench excavation (one B-12 and five B-88 waste boxes). Waste streams that will be sent to Envirocare include soils that are contaminated below LDR levels (52 B-88 waste boxes).

5.2 Debris

Disposal of the debris waste stream (three B-12 and six B-88 waste boxes) at Envirocare will also be pursued. As discussed in Section 2 of this report, this waste stream is LDR compliant and can legally be disposed at Envirocare. However, because of the elevated level of PCBs detected in the debris, Envirocare may decline to accept it. If this proves to be the case, the debris waste stream will be treated along with the radioactive metal wastes and soils contaminated above LDR levels.

5.3 Decanted Lathe Coolant

Two of the three drums of decanted lathe coolant will be treated onsite at the CWTF located in Building 891. These two drums have already been transferred to the CWTF and are awaiting treatment. Because the concentration of Aroclor-1254 detected in the organic top phase in the third drum exceeded the CWTF's acceptance criteria for this contaminant, the third drum will be treated along with the radioactive metal and soil wastes (see below).

5.4 Non-LDR-Compliant Wastes

Five Trench 1 waste streams exceed LDR levels and must be treated. These include the DU waste (130 overpack drums and 24 B-12 waste boxes), the thorium waste (one overpack drum and one B-12 waste box), the "historic sample waste" (one B-12 waste box), the contaminated soil (11 B-88 waste boxes), and the cemented cyanide waste (11 drums). The evaluation of offsite treatment alternatives indicates there are no facilities able to treat any of these five waste streams at this time. One offsite treatment facility within the DOE Complex, the TSCA Incinerator at ORNL, is able to treat the wastes from a technical and regulatory standpoint. However, a moratorium by the State of Tennessee regarding the acceptance of out-of-state wastes at this facility is currently in place. The time frame for the lifting of this moratorium is unknown. Seven offsite commercial facilities were identified and evaluated. However, none of the seven facilities currently possess all of the necessary permits and licenses to treat the cemented cyanide, radioactive metal, or soil wastes.

5.4.1 Cemented Cyanide Waste

Two facilities, Perma-Fix and WCS, appear to be approximately less than six months away from obtaining the required permits and license modifications to treat the cyanide wastes. All seven of the commercial facilities identified could likely treat the cemented cyanide using the RCRA treatability study exemption. A thorough evaluation will be completed to determine the best offsite facility to receive and treat the cemented cyanide waste. Barring any unforeseen circumstances, the Trench 1 cemented cyanide wastes should be shipped to an offsite facility prior to the end of Fiscal Year 1999.

5.4.2 Radioactive Metal and Soil Waste

As noted above, no offsite facilities possess all of the necessary permits and licenses to treat the radioactive metal and soil wastes at this time. Four of the commercial facilities identified are currently working toward obtaining the permits and licenses to treat this waste stream. ATG-Richland and WCS are estimated to be 12-24 months away from being authorized to treat RCRA/LLW/TSCA wastes.

Although offsite treatment cannot be conducted at this time, ATG-Richland, WCS, M&EC, and Perma-Fix are presently permitted or should be permitted this fiscal year for the storage of the Trench 1 radioactive metal and soil waste streams. Storage of these wastes at an authorized facility awaiting regulatory approval for treatment would allow storage of the waste at an indoor facility prior to treatment at that location. The radioactive metal and soil waste is presently being stored outdoors at the Trench 1 project site on an interim basis in a compliant manner. However, indoor storage at an offsite facility is preferred to storage at RFETS (i.e., progress toward site closure). Offsite storage will also eliminate onsite inspection and maintenance costs.

Onsite treatment of the radioactive metal wastes and contaminated soil has been eliminated from consideration. Although batch vitrification and steam reforming may be technically feasible, there are a number of issues associated with their implementation at RFETS. Because both are thermal processes, a variety of air emission issues exist with Clean Air Act requirements as well as negative public perception and safety concerns regarding the operation of thermal units at RFETS. Also, treatability testing is necessary prior to making an affirmative project-specific determination with respect to the effectiveness of treatment. Finally, it is estimated that implementation of an onsite treatment project would require approximately 18 months to complete.

Safe interim storage and future treatment and disposal at an approved and permitted offsite commercial facility is the best path forward for the radioactive metal and soil waste streams. A contractual arrangement with a commercial facility for storage and future treatment and disposal of the wastes will be pursued this fiscal year, barring any unforeseen circumstances.

6.0 REFERENCES

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TABLES

TABLE 2-1
T-1 SOURCE REMOVAL WASTE/MEDIA DISPOSITION

Waste Type	Regulatory Classifications	Sample RIN	Packaging	Container numbers (Secondary overpacks, if used, are not listed)	Interim Storage	Expected Disposition	Sampling: Analysis/Media	Volume or weight
Soil (<5,000 CPM, OVA < 25 ppm above background)	Not considered waste	98A2112	not packaged	N.A.	Stockpile 1	Returned to T-1	Sampled per section 3.2.1 of the RMRS SAP	1093.4 yd^3
Soil (≥ 5,000 but ≤ 10,000 CPM, OVA < 25 ppm above background)	CERCLA Waste LLW, Hazardous Waste (F001, F002). Bulk PCB remediation waste.	98A2113	22 - B-88s	X09698, X09699, X09700, X09701, X09702, X09703, X09704, X09705, X09706, X09707, X09708, X09709, X09710, X09711, X09718, X09719, X09720, X09721, X09722, X09723, X09724, X09725	Stockpile 2 then transferred to B-88s	Envirocare	Per Section 3.3.2 of the RMRS SAP	78.1 yd^3 201,910 lbs
Soil (>10,000 CPM, OVA < 25 ppm above background)	CERCLA Waste LLW, Hazardous Waste (F001, F002). Bulk PCB remediation waste.	98A2114	30 - B-88s	X09712, X09713, X09714, X09715, X09716, X09717, X09727, X09728, X09729, X09730, X09731, X09732, X09734, X09737, X09738, X09739, X09741, X09742, X09747, X09748, X09749, X09750, X09751, X09753, X09754, X09757, X09759, X09762, X09763, X09764	T-1 Waste Container Staging Area	Envirocare	Per Section 3.3.2 of the RMRS SAP	106.5 yd^3 280,282 lbs
Soil (OVA ≥ 25 ppm above background)	CERCLA Waste LLW, Hazardous Waste (F001, F002). Bulk PCB remediation waste.	98A2116	11, B-88s	IDC 374 (SOIL): X09761, X09752, X09758, X09746, X09755, X09756, X09745, X09743, X09744, X09735, IDC 325 (Mixed IDCs): X09726	T-1 Waste Container Staging Area	Treatment with T-1 DU	Per Section 2.2.3 of the RMRS SAP	39.1 yd^3 95,046 lbs
Decanted Lathe Coolants	CERCLA Waste LLW, Hazardous Waste (F001, F002) Low PCBs (.09U- 0.21 ppm, Aroclor 1254)	98A2106	2 55 gal	X07938 X07927	T-1 Waste Container Staging Area	Building 891	Per Section 3.3 of the STARMET SAP	110 gal
Decanted Lathe Coolants	CERCLA Waste LLW Hazardous Waste (F001,F002) TSCA - PCBs (76 - 112 ppm, Aroclor 1254)	98A2106	1 55 gal	X07935	T-1 Waste Container Staging Area	Treatment with T-1 DU	Per Section 3.3 of the STARMET SAP	<15 gal

TABLE 2-1 (CONT)
T-1 SOURCE REMOVAL WASTE/MEDIA CHARACTERIZATION

Waste Type	Regulatory Classifications	Sample RIN	Packaging	Container numbers (Secondary overpacks, if used, are not listed)	Interim Storage	Expected Disposition	Sampling: Analysis/Media	Volume or weight
Depleted Uranium	CERCLA Waste LLW Hazardous Waste (F001, F002, D006) PCB Remediation waste	98A2105	See column at right	76 - 55 gallon overpacks: D87702 D88413 D88407 D88417 D87699 D88425 D88387 D88388 D88418 D88414 D88410 D88415 D87710 D88405 D88416 D88412 D88419 D88420 D88406 D92869D92857 D92858 D92864 D92860 D92861 D92859 D92865 D92868 D92863 D92862 D92854 D92855 D92870 D92853 D92871 D92866 D92852 D93262 D93269 D93264 D93274 D93270 D93271 D93276 D93266 D93282 D93260 D92856 D93259 D93261 D93263 D92867 D93273 D93265 D93275 D93268 D93281 D93272 D93267 D93278 D93279 D93283 D93285 D93277 D93287 D93286 D93288 D93284 D93280 D93462 D93450 D93457 D93461 D93466 D93469 and D87713 - (sample returns)	T-1 Waste Container Staging Area	DU Treatment Project	Per Section 3.2 of the STARMET SAP	11.4 yd^3 24,206 lbs (includes original 30 gal drum, DU)
				48 - 83 gallon overpacks: X09875 X09835 X09837 X09840 X09838 X09850 X09843 X09872 X09867X09868 X09865 X09877 X09841 X09869 X09870 X09894 X09871 X09866 X09845 X09844 X09880 X09874 X09860 X09862 X09884 X09878 X09883 X09853 X09855 X09879 X09887 X09882 X09853 X09854 X09876 X09857 X09886 X09888 X09885 X09864 X09863 X09851 X09893 X09875 X09856 X09890 X09842 X09839				13.1 yd^3 25,976 lbs (includes original 30 and 55 gal drum, DU)
				5 - 85 gallon overpacks: X10374 X10371 X10398 X10375 X10372				3,045 lbs
				1 - 110 gallon overpack: X10058				1,092 lbs
				24 - B12s: X09834 X09833 X09805 X09822 X09821 X09798 X09801 X09809 X09810 X09800 X09804 X09799 X09803 X09806 X09826 X09807 X09828 X09827 X09808 X09832 X09830 X09831 X09825 X09824				47 yd^3

TABLE 2-1 (CONT)
T-1 SOURCE REMOVAL WASTE/MEDIA CHARACTERIZATION

Waste Type	Regulatory Classifications	Sample RIN	Packaging	Container numbers (Secondary overpacks, if used, are not listed)	Interim Storage	Expected Disposition	Sampling: Analysis/Media	Volume or weight
DU - Ingot ("Puck")	CERCLA Waste LLW	not sampled	83 gal	55 gal D93471 overpacked into 83 gal X10906 overpack	T-1 Waste Container Staging Area	NTS	not sampled	<0.5 ft^3 163 lbs
Thorium waste	CERCLA Waste LLW Hazardous Waste (F001, F002) PCB Remediation waste	98A2105	1 83 gal 1 B-12	X09852 (overpack X11067, IDC 140) X09823 (IDC 374)	T-1 Waste Container Staging Area	DU Treatment Project	Per Section 3.2 of the STARMET SAP	0.27 yd^3 497 lbs & 1.96 yd^3 5090 lbs
HISTORIC SAMPLES UH$_3$ (Natural uranium) and TU (assumed DU tubaloy)	CERCLA Waste LLW Hazardous Waste (F001, F002)	98A2105	1 B-12	X09829 (IDC 374)	T-1 Waste Container Staging Area	DU Treatment Project	Per Section 3.2 of the STARMET SAP	1.96 yd^3 4850 lbs
Cemented Cyanide	CERCLA Waste LLW Hazardous Waste (F006, F008, D006) TSCA-Asbestos waste	98A2109	10 55 gal 1 83 gal	IDC 823: X10401 X10397 X10390 X10399 X10373 X10377 X10376 X10393 X10388 X10382 IDC 325: X09903 (drum lids, rings sample equip, PPE used in CN tasks)	T-1 Waste Container Staging Area	Cemented Cyanide Treatment Project	Per Section 3.5 of the STARMET SAP	2.7 yd^3 6294 lbs 0.4 yd^3 81 lbs
Debris	CERCLA Waste LLW Hazardous debris waste (F001, F002). PCB remediation waste.	98A2117	6 - B-88's 3 - B-12's	B-88's: X09736 (sampled), X09733, X09740, X09760, X09701, X09726 B-12's: X09832, X09795, X09796	T-1 Waste Container Staging Area	Envirocare or DU Treatment project	Per Section 3.4 of the RMRS SAP	21.3 yd^3 17,634 lbs 5.9 yd^3 3,704 lbs
PPE Waste	CERCLA Waste LLW	Not Sampled	1 B-12 5 B-88	B-12: X09794 B-88: X09695 X09696 X09697 X11519 X11520	T-1 Waste Container Staging area	NTS	Sampling not required per process knowledge	19.7 yd^3 7934 lbs

Table 3-1
Permit and License Status of Offsite DOE Facilities and Projects

DOE Facility	RCRA Permit	TSCA Permit	Radioactive Materials License	T1 Wastes Meet WAC	Comments
TSCA Incinerator Oak Ridge, TN	Yes	Yes	Yes	Yes	Current moratorium on the acceptance of out-of-state wastes. Overbooked solids treatment capacity.
M-Area Vitrification Plant Savannah River, SC	Yes	No	Yes	No. VOC content too high. Metallic solids not accepted.	WAC limit for organic contaminants is very low. Facility does not include an off-gas treatment system for VOCs.
WERF Idaho Falls, ID	Yes	No	Yes	No. PCB's not accepted.	

TABLE 3-2
Permit and License Status of Offsite Commercial Facilities

Offsite Facility	RCRA Permit	RCRA Treatability Study Exemption (limited to 10, 000 Kg)	TSCA Permit	TSCA RDD Permit	Radioactive Materials License	CERCLA Off-site Approval	K/H Due Diligence	Clean Air Act Permit	All Req'd Equipment in Place	Presently Able to Treat Trench 1 Wastes?	Facility Storage Capability
Materials & Energy Corp Oakridge, TN	Applied for in June 1998, Part B permit to include 7 processes (including capability to treat T-1 DU wastes); Permit expected in Summer 1999.	Could perform Treatability study; requires 45 day notification period to the State. Lab -scale equipment only.	Applied for in June 1998, *Permit expected* in Summer 1999.	No, not *pursuing.*	Presently operate under DOE Orders since facility is located at DOE Site; Radioactive Materials License applied for and approval is expected by 1/31/99. License will allow up to 80 Ci of DU material.	No	No	Expected in March 1999; not required to perform Treatability Study.	No	No, required Permits and Licenses are not in place.	Yes
ATG-Richland Richland, WA	Applied for RCRA/TSCA *permit 2/98;* Draft permit expected to be issued 1/99. Full permit issue expected in April 1999, *Effective May 1999.*	*Could perform Treatability* Study, however, ATG prefers to wait for issuance of Final Part B in May 1999	Permit expected in May/June 1999, permit will require thermal treatment for PCB's.	No	YES; can receive up to 10,000 kg of Source Material. Can submit project specific License Amendment to allow greater quantities of material-expect 3-4 weeks for Amendment Approval.	Yes	No	Expected to be issued with RCRA permit. Will require verification by K-H Compliance Group.	No	No; T-1 waste will exceed 10,000 kg requirement for Rad. Material License, additionally, RCRA/TSCA permits are not presently in place. Capability to treat T-1 cyanide wastes potentially in place by May 1999. Ability to treat T-1 DU wastes with Vitrification potentially by 1st QTR 2000. ATG must demonstrate process prior to full operation.	Yes
Perma-Fix Gainesville, FL	Yes; existing Part B permit allows for blending/bulking only; Revision to Part B will allow treatment-intent to issue expected Feb 99, then 45 day wait period	Could perform Treatability Study.	Application for Storage *made* in Fall 1998, approval expected Spring 99; No treatment Permit; but could depend upon National TSCA permit from other mobile unit.	YES, but must dispose at "pre-treated" levels.	YES; can receive up to 0.1 microcuries/gm for source material, and up to 200 nanoCi for DU. Can submit Project specific mod., expect 1-3 weeks.	Yes	Yes	Will require verification by K-H Compliance Group.	No	No; T-1 DU waste will exceed both specific activity requirements. RCRA/TSCA treatment permits are not presently in place. T-1 cemented cyanide wastes will presently meet WAC or could be accepted under a RCRA Treatability Study exemption.	Yes
DSSI Kingston, TN (liquid waste capability only)	Yes, existing permit is for liquids (<5 micron solids). Permit Modification for solid waste to be submitted 2/99. Approval of permit anticipated in 12-24 months. Permit will cover stabilization only.	Yes, could perform Treatability Study.	No, but could depend upon National TSCA *permit from other* mobile unit.	No	Yes, approved for Solidification Process only (up to 10,000 cubic feet per year).	Yes	Yes	Yes	Yes	Solid waste does not meet WAC; however, drained and bulked mineral oil should meet WAC.	No
Starmet, CMI Barnwell, SC	No	Yes, could perform Treatability Study.	No	No	Yes	Yes	Yes	Yes	Yes	No, Starmet cannot receive RCRA or TSCA wastes.	No
Waste Control Specialists Andrew, TX	Yes; permit allows for stabilization/solidification and chem. oxdn/redn. Permit modification required for treatment of T-1 DU wastes (add thermal desorb/oxdn estimate 12-24 months).	Yes, could perform Treatability Study of RCRA-only materials. Rad. License Amendment (2-3 months) required prior to accepting T-1 cyanide wastes.	No; Will submit TSCA permit application in Feb 99, anticipate 12 *months for approval.*	No	Yes; requires Amendment to allow for new treatment processes (i.e. chem oxdn., Thermal desorb., etc.) 2-3 months expected.	Yes	Anticipated 2/98	RCRA Part B permit incorporates Clean Air Provisions.	No	Not presently. RCRA/TSCA permit limited	Yes
Envirocare of Utah Clive, UT	Yes; permit allows for stabilization/solidification. Permit modification would be required for treatment of T-1 DU wastes (estimate 12-24 months).	Yes, could perform Treatability Study. Stabilization equipment available only.	No	No	Yes	Yes	Yes	Would require modification to permit for new treatment process.	No	No, Could not handle the TSCA-regulated materials. RCRA permit does not presently allow for required treatment processes to handle T-1 DU wastes.	No

Table B-1

Budgetary Cost Estimate
Batch Vitrification of Trench 1 Wastes at RFETS

	Cost
I. Planning	
Document Preparation[1]	87,200
Ace Review	21,600
II. Treatability Study	
Plan Preparation	20,000
Pilot Vitrification	60,000
Test Report	16,000
Mobilization	
Transport and Assemble Equipment	220,000
Plant Power Modification	18,000
Cell Construction	30,000
Readiness Review	16,000
III. Treatment	
Treatment @ $2,000 per ton[2]	312,480
Electrical Power	N/A
Breakup and Containerize Product	15,000
RMRS Field Support	288,000
IV. Analytical	250,000
V. Demobilization	130,000
VI. Disposal	236,008
VII. Project Closure and Final Report	22,800
Subtotal	1,743,088
Contingency @ 15%	261,463
Total Estimated Cost	**2,004,551**

Table B-1 (cont)

Budgetary Cost Estimate
Batch Vitrification of Trench 1 Wastes at RFETS

Cost Estimating Assumptions

[1]Includes the preparation of the following project-specific documents:

Proposed Action Memorandum (PAM), Field Implementation Plan (FIP), Integrated Work Control Package (IWCP), Design and Operating Plan, Hazard Analysis Report, Health and Safety Plan (HASP), and the Sampling and Analysis Plan (SAP)

[2]Treatment cost estimate is based on the vitrification of approximately 156 tons of radioactive metal and soil waste consisting of 130 overpack drums, 29 B-12 containers, and 11 B-88 containers. Cost estimate includes all associated field labor, health and safety, and radiological monitoring support.

Table B-2

Elapsed Schedule for Onsite Treatment of Trench 1 Radioactive Metal and Soil Wastes

Activity	Duration (months)
Procure Treatment Services Prepare Statement of Work Evaluate bids Negotiate and award subcontract	4
Project Documentation and Planning Proposed Action Memorandum Health And Safety Plan Field Implementation Plan Integrated Work Control Package Sampling and Analysis Plan APEN	3.5
Conduct Treatability Study	3[1]
Mobilization, Training, Setup, and System	1.5
Treatment and Waste Packaging	2
Decontamination/Demobilization	1
Waste Disposal	3
TOTAL DURATION	15-18

[1] If necessary.

FIGURES

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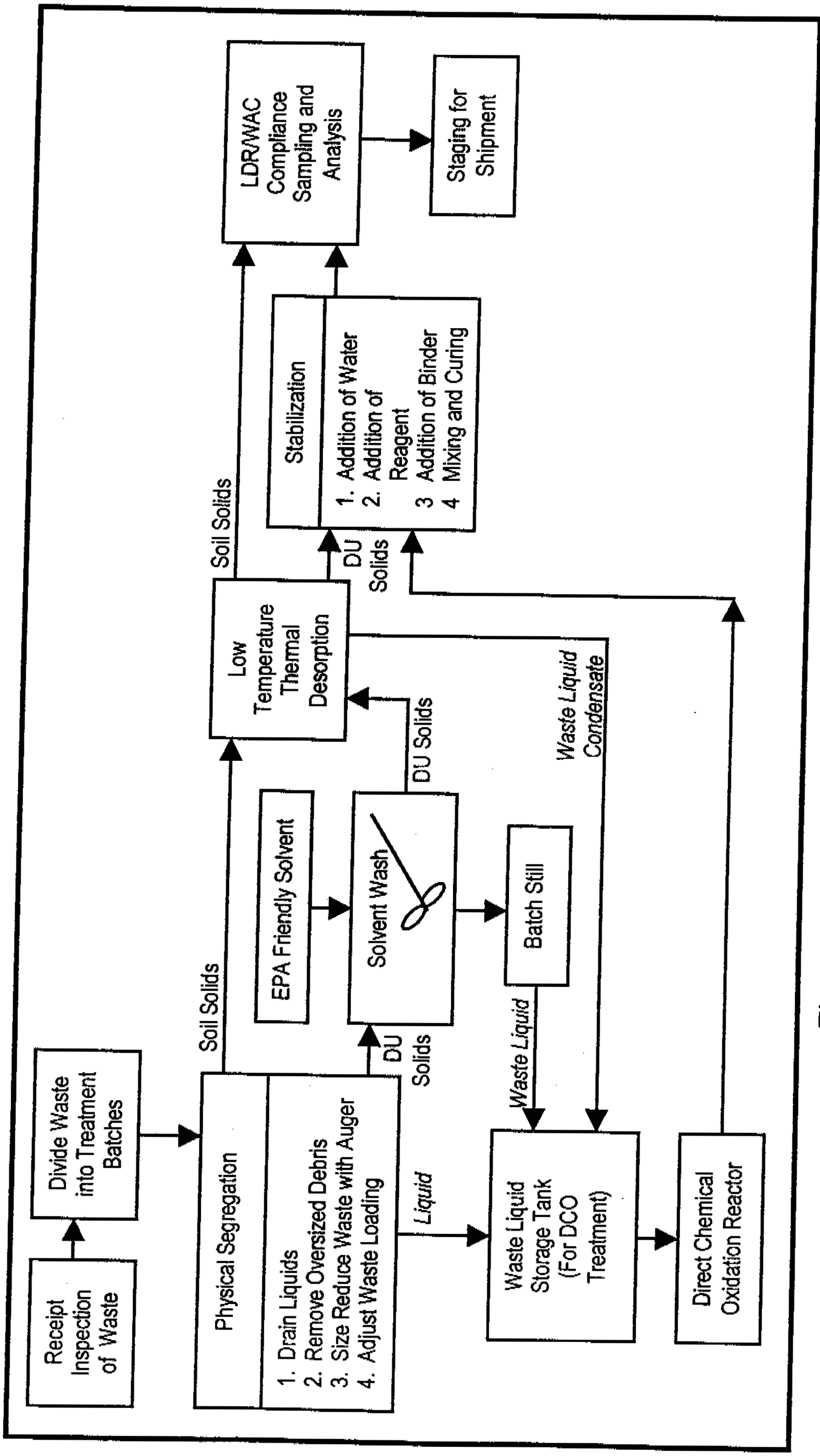

Figure 2 - Materials & Energy Corporation
Proposed Treatment Flowsheet For Depleted Uranium and Contaminated Soil

GeoMelt Stationary Batch System Schematic

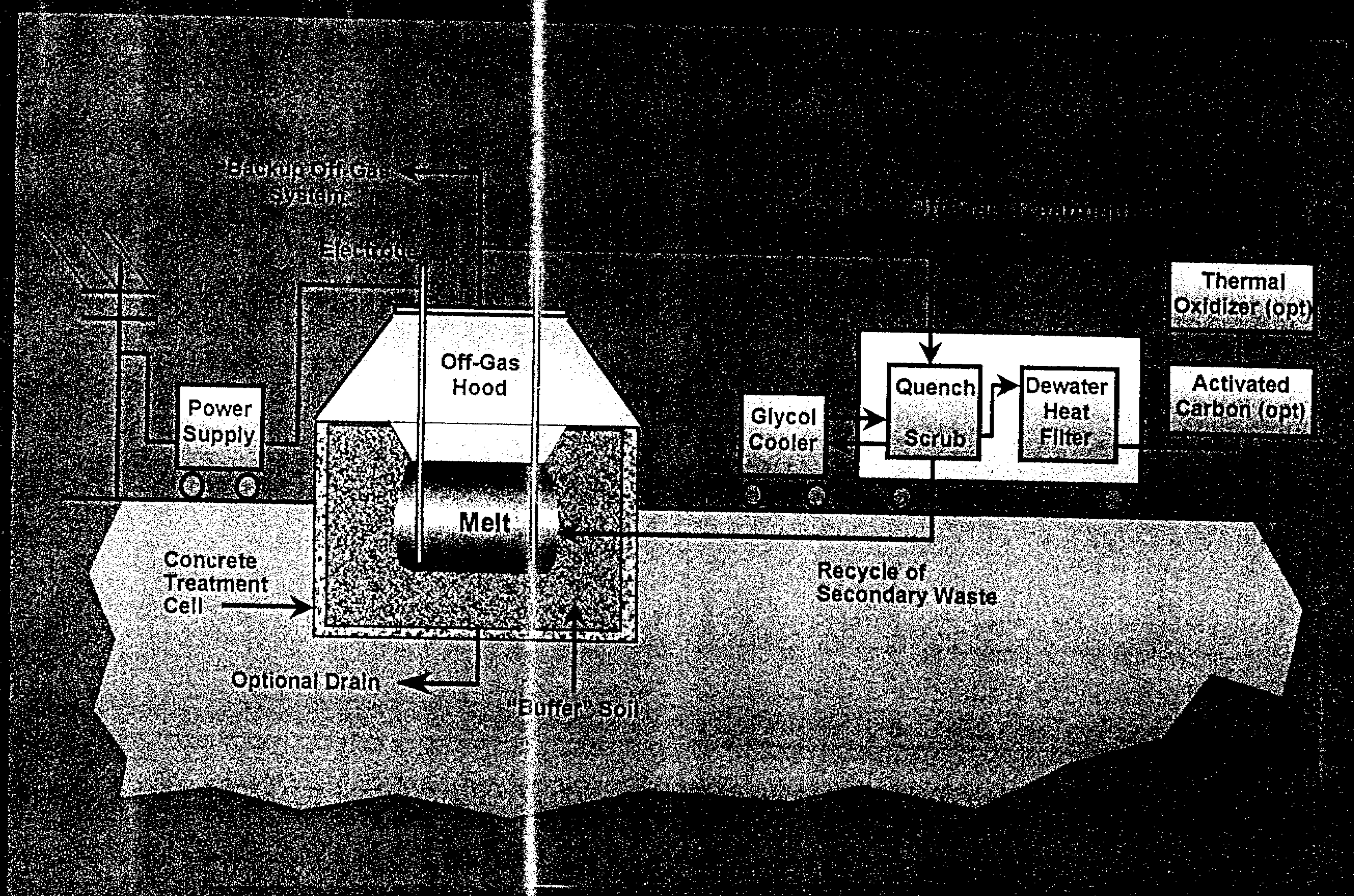

Figure 3 - Geosafe Batch Vitrification Flowsheet

Geosafe Corporation

Best Available Copy

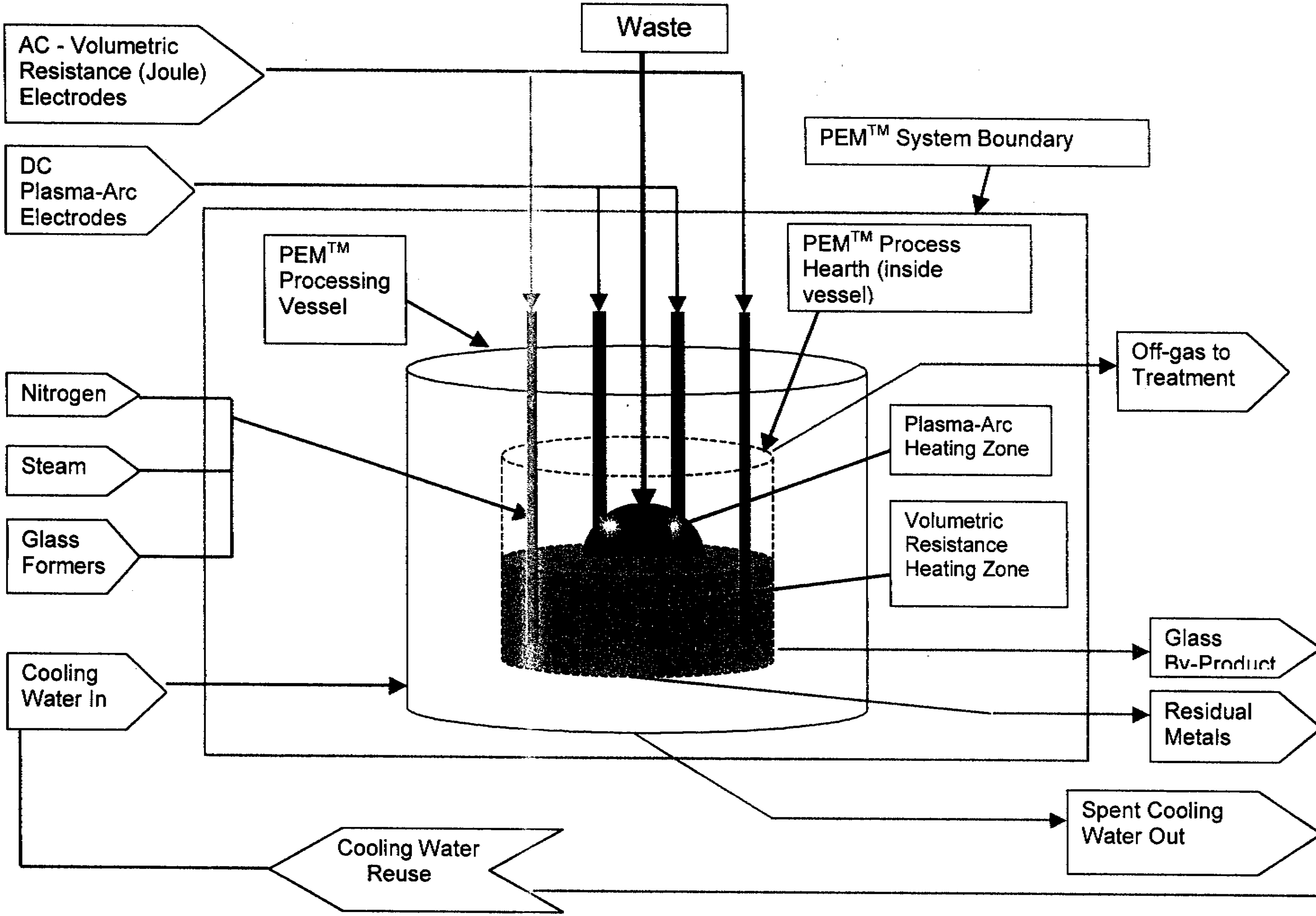

Figure 4 - ATG Plasma Arc Vitrification Unit

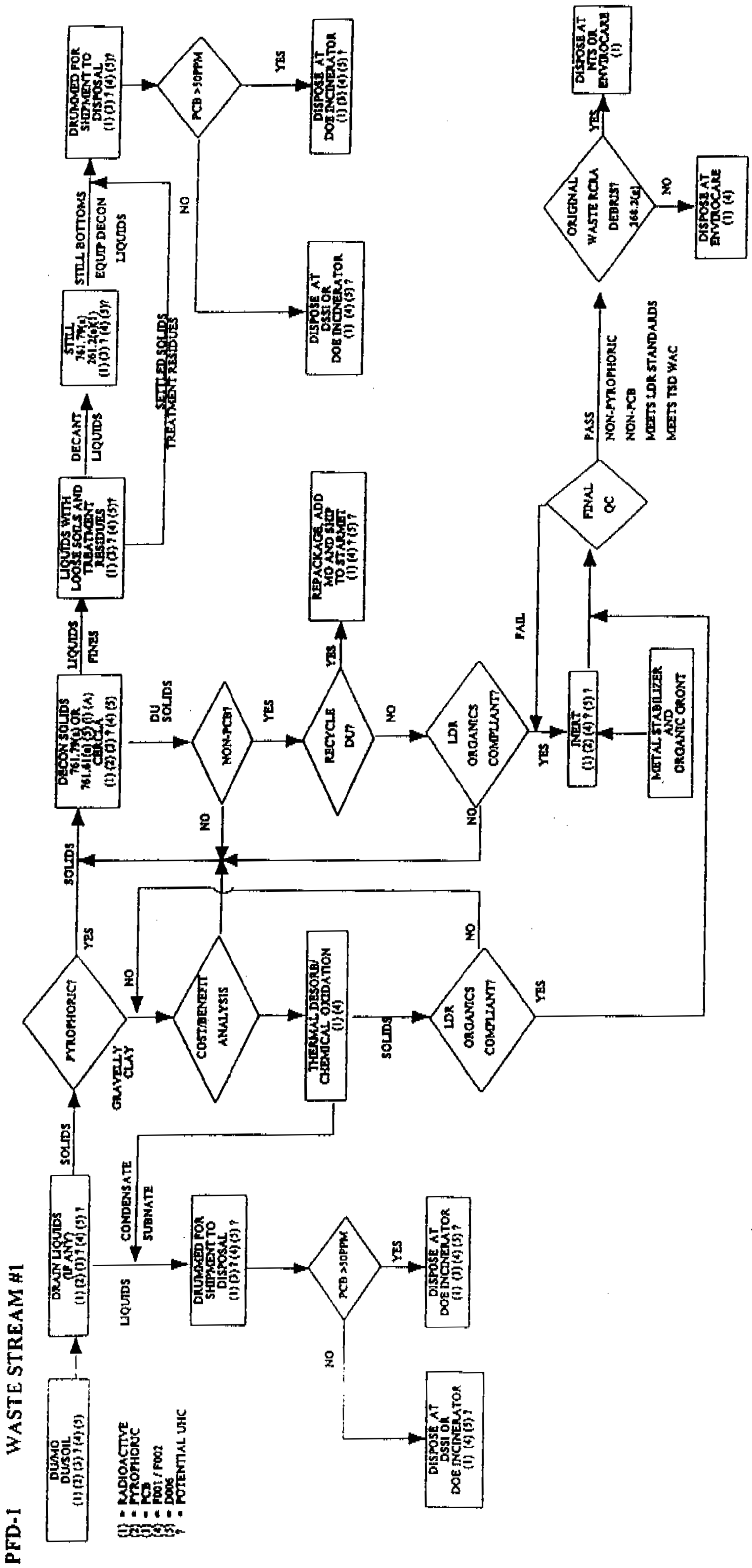

Figure 5
Perma-Fix Process Flowsheet

Appendix A

CBD Announcement
Final 11/20/98

PART: U.S. GOVERNMENT PROCUREMENTS
SUBPART: SERVICES
CLASSCOD: C--Architect and Engineering Services - Construction--Potential Sources Sought
OFFADD: Rocky Mountain Remediation Services, L.L.C., Rocky Flats Environmental Technology Site, P.O. Box 464, Golden, Colorado 80402-0464
SUBJECT: C--TREATMENT AND DISPOSAL OF DEPLETED URANIUM, SOIL, AND CYANIDE WASTES
SOL RM-SS-01
DUE 121498
POC Technical: Robert Cygnarowicz (303) 966-7916 or Procurement: Karen Fairchild (303) 966-4726
DESC: The Closure Management Division of Rocky Mountain Remediation Services, L.L.C. (RMRS) is currently planning for the treatment and disposal of depleted uranium (DU), soil, and cemented cyanide wastes that were excavated during a CERCLA removal action from Trench 1 at the Rocky Flats Environmental Technology Site (RFETS). RFETS is located approximately 16 miles northwest of Denver, Colorado.

Waste Stream #1: The DU wastes (approximately 30 tons) range from hard/compacted solids to sludges and pastes and are classified as Atomic Energy Commission source material. U-238 activities in these wastes typically range from 150,000 to 340,000 pCi/g. Excavated drums of DU have been overpacked into 160 steel drums and 29 steel waste boxes (1.6 cubic yards each). Mineral oil has been added to the drummed waste to temporarily inert the potentially pyrophoric DU. Soil has been added to the boxed waste for the same purpose. The DU wastes are contaminated with F-listed chlorinated solvents, semi-volatile organic compounds, polychlorinated biphenyls (PCBs), and metals. The primary contaminants of concern are tetrachloroethylene (PCE), trichloroethylene (TCE), Aroclor 1254, and cadmium. The pyrophoric nature of the DU is also of primary concern. PCE and TCE detections range from non-detect levels to 20 weight percent and 1 weight percent, respectively. Aroclor 1254 analytical results range from non-detect to 1,700 parts per million (ppm). Toxicity Characteristic Leachability Test (TCLP) results for cadmium were observed at levels up to 35 milligrams per liter (mg/l).

Approximately 36 cubic yards of contaminated soil may be added to the DU waste stream described above. This soil is described as a gravelly clay and contains some debris (i.e., metal, plastic, etc.). The contaminated soils have been containerized in ten steel waste boxes (3.6 cubic yards each). The soils are contaminated with DU and organic compounds. U-238 was detected at activities ranging from less than 100 pCi/g to 4,000 pCi/g and PCE was detected at concentrations ranging from less than 1 ppm to 51 ppm. Aroclor 1254 was detected in nearly all soil samples collected, however, all concentrations reported were below the 50 ppm TSCA regulatory limit. The contaminated soils are not considered pyrophoric. The DU and soil wastes require treatment in accordance with Land Disposal Restriction (LDR) requirements for F001 and F002 wastes.

Waste Stream #2: Ten drums of cemented cyanide waste that were excavated from Trench 1 have been overpacked into steel drums. The cemented cyanide wastes are described as damp-to-wet unsolidified, granular, paste-like solids that contain asbestos fibers. Cyanide (total) contamination was detected in the waste from 0.5 to 5.3 percent by weight. The waste also exceeds regulatory thresholds for cadmium with TCLP cadmium concentrations ranging from 829 to 1,200 mg/l. The cemented cyanide wastes also contains low levels of uranium contamination. U-238 activities up to 117 pCi/g were observed in this waste stream. No volatile or semi-volatile organic compounds were detected in the cemented cyanide waste. The cemented cyanide waste stream requires treatment in accordance with Land Disposal Restriction (LDR) requirements for F006 and F008 wastes.

As part of a market survey, RMRS is soliciting technical and regulatory permit information regarding onsite and offsite services and equipment that are appropriate for the treatment and disposal of the Trench 1 waste streams described above. This information shall include, but not necessarily be limited to: technical specifications, treatment process flowsheets, statements of qualifications, similar project experience descriptions, treatment system performance data, treatability testing capabilities, size reduction and materials handling equipment and capabilities, permits, and waste acceptance criteria (i.e., offsite facilities). The ultimate goal of treatment is to allow the wastes in question to be transported to an offsite, permitted facility for final disposal.

The waste streams, including secondary waste streams generated by any treatment processes, must be treated and disposed of by no later than September 30, 1999. Waste treatment may be performed at RFETS, but RMRS prefers for the waste to be treated at an off-site facility. If off-site treatment is proposed the submittal must describe the regulatory structure under which the waste will be treated; describe all required permits; include a corporate officer's certification stating all required permits are current and will be valid through September 30, 1999; include the facility's waste acceptance criteria; and include a copy of EPA's CERCLA off-site rule authorization letter.

Due to the nature of the work, RMRS is interested in proven technologies and methods for treating and disposing of the Trench 1 wastes described above. Demonstrated experience in treating and managing hazardous and radioactive wastes is necessary. A working knowledge of and demonstrated compliance with DOE, EPA, and OSHA regulations is also necessary.

This advertisement is NOT A SOLICITATION for services. Responses to this advertisement will be evaluated for the purpose of developing a list of vendors to which a Request for Proposal will be issued at a later date. All submittals shall be received no later than 4:30 P.M. (MST) on December 14, 1998. Submit responses and inquiries to Rocky Mountain Remediation Services, L.L.C., Rocky Flats Environmental Technology Site, P.O. Box 464, Golden, Colorado 80402-0464, Attention: Robert Cygnarowicz, Building T893B, (303) 966-7916.
CITE:

Appendix B

EVALUATION OF ONSITE TREATMENT ALTERNATIVES

for

TRENCH 1 RADIOACTIVE METAL AND SOIL WASTES

Appendix B
TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

B.0 EVALUATION OF ONSITE TREATMENT ALTERNATIVES FOR TRENCH 1 RADIOACTIVE METAL AND SOIL WASTES

The search for alternatives to treat Trench 1 radioactive metal wastes and contaminated soils identified six onsite treatment alternatives (i.e., implementation at RFETS). These alternatives are evaluated in detail in this appendix with respect to their effectiveness in achieving regulatory-driven treatment goals as well as the challenges associated with implementing the alternative at RFETS. The evaluation concludes with a comparative analysis of the results of the evaluations which identifies two onsite alternatives with the most potential for onsite treatment of the Trench 1 wastes in question.

The vendors offering an onsite treatment alternative along with the treatment technologies included in the alternatives are summarized below.

Respondent	Proposed Treatment Technologies
GTS Duratek	Steam Reforming, Solvated Electron Dechlorination Technology, and Stabilization.
Materials and Energy Corporation	Solvent Extraction/Direct Chemical Oxidation, Thermal Desorption, and Stabilization.
Geosafe Corporation	Batch Vitrification.
ATG	Continuous Plasma Arc Vitrification.
Perma-Fix	Thermal Desorption, Direct Chemical Oxidation, and Stabilization.
Starmet	Solvated Electron Dechlorination Technology, and Thermal Oxidation

B.1 GTS Duratek

Process Description. GTS Duratek proposes that the radioactive metal and soil wastes be treated with a combination of steam reforming technology and solvated electron technology (SET) as illustrated by the process flowsheet presented in Figure 1. The flowsheet indicates that the mineral oil is first removed from the drummed waste. The solids are then "size reduced" and separated into various size fractions. Size reduction and separation activities are performed under an inert atmosphere because of the potentially pyrophoric nature of the DU wastes. Solids and debris larger than 6 cm are treated in the steam reforming unit. Solids less than 6 cm and liquids (including the mineral oil separated in the first step) are treated in the SET unit. The DU and soil wastes contained in B-12 and B-88 waste boxes are also treated in the SET unit. Following dechlorination in the SET unit, the solids are treated in the steam reformer where they are oxidized to eliminate the pyrophoric characteristic of the DU. The wastes are then stabilized to eliminate the toxicity characteristic associated with the leachability of cadmium. Empty drums and waste boxes are decontaminated to remove residual contamination and are subsequently managed as empty containers.

The steam reformer proposed by GTS Duratek is a batch process that consists of two primary units: an evaporator and a reactor. The evaporator unit employs superheated steam at approximately 1100°F to evaporate liquids and strip organic contaminants from the solid waste matrix. Chemical reaction between the high-temperature water vapor and the organic contaminants begins to occur in the evaporator which serves to crack heavier organic compounds into smaller, more volatile constituents. The degradation reactions are especially helpful in aiding the volatilization of PCBs (normal boiling point approximately 750°F) from the solid waste matrix.

The resulting steam and organic vapor mixture is drawn through a high temperature particulate filter and introduced into an electrically-heated reactor where the temperature of the vapor is raised to approximately 2,000°F. Water is extremely reactive at this temperature and the degradation reactions that begin in the evaporator unit are taken to completion. The result is a mixture comprised of simple gases such as hydrogen, carbon dioxide, carbon monoxide, methane, hydrochloric acid, ammonia, and water vapor. This offgas is quenched and treated appropriately prior to venting to the atmosphere.

The SET unit proposed by GTS Duratek is offered through Commodore Advanced Sciences, Inc. It is a pressurized, batch mixing unit that commingles solid wastes with a highly reductive liquid solution that serves to dechlorinate organic contaminants present in the waste. Each chlorine atom is displaced by a hydrogen atom, thus, transforming chlorinated organic compounds into non-regulated hydrocarbons. The reductive solution is formed by the dissolution of an alkali metal such as sodium in liquid anhydrous ammonia. The result is a solution charged with "solvated" or free electrons that are needed to drive the dechlorination reaction forward. Pressurization of the mixing unit is required to maintain the liquid state of the ammonia. After the dechlorination reactions are complete, the pressure is reduced to allow the ammonia to vaporize. The reaction products remaining in the solid waste matrix are dechlorinated hydrocarbons and chloride salts.

Process Evaluation. Both steam reforming (Gibson, 1997) and SET (Commodore, 1998) have been found to be effective in reducing the concentrations of chlorinated solvents and PCBs required to meet Land Disposal Restrictions. An important advantage of both treatment technologies is that the regulated organic contaminants present in feedstock wastes are eliminated. This is in contrast with a physical separation process that concentrates the contaminants in a secondary waste stream which must be further treated. In the case of steam reforming, the desorbed organic contaminants are destroyed to simple gases by reacting them with superheated steam. With SET, the regulated contaminants are transformed into non-regulated hydrocarbons. Steam reforming technology has the added advantage of oxidizing the DU (Waber, 1956), and thus, eliminating the pyrophoric nature of the wastes.

For these two treatment technologies to be effective, however, adequate surface area contact between the solid waste matrix and the reagent (i.e., superheated steam or solvated ammonia solution) is required. The proposed process addresses this need by crushing and fractionating the wastes prior to treatment. The larger size fraction is processed in the reformer unit where mechanical mixing is not available to expose waste surfaces. Smaller solids, sludges, soils, and oils are processed in the SET unit which provides mechanical mixing. There is uncertainty, however, that the degree of solid-reagent contact necessary for effective treatment will be achieved in the SET unit when processing oily sludges and pastes. "Channeling" is likely to occur in these wastes which will serve to limit the surface area of the solid waste exposed to the liquid reagent.

The proposed feedstock preparation activities should enhance the overall waste-reagent contact achieved in the treatment operation. As noted above, however, whether the feed preparation measures will be sufficient to ensure that treatment goals will be met is uncertain. Nonetheless, the proposed size reduction and size separation activities proposed for the Trench 1 wastes have three important disadvantages. These include worker exposure, equipment shutdown, and equipment decontamination. The potential for exposing workers to contamination is significant considering the need to transfer the wastes from the drums to the feedstock preparation equipment and from treatment unit to treatment unit.

It should also be noted that transferring the contents of approximately 25 drums will prove to be extremely challenging. The drums in question contain extremely hard DU metal wastes. Repeated blows with a non-sparking chisel were required to obtain samples from these drums. It is speculated that the DU waste chips placed in these particular drums have fused into hard monoliths as a result of oxidation. The hard and dense nature of the monoliths presents a considerable challenge with respect to removing the contents of the drum. The drum in which the wastes have been buried may have to be cut away from the contents which significantly increases the time that workers are in close proximity to the wastes.

In contrast, shredding entire drums along with their contents may decrease worker exposure to contamination by reducing the amount of manual handling required. A shredding operation may, however, increase the chance of equipment shutdown (e.g., jamming, plugging, etc.). In such an event, the benefit of reduced worker exposure gained by shredding would be offset by the exposure realized in resolving the cause of the shutdown and possibly making repairs to contaminated equipment. Even in the absence of a shredding operation, shutdown and damage to the size reduction equipment proposed, and subsequent worker exposure to make it operational, is of particular concern considering the fused DU wastes described above. Plugging of screening equipment by the oily sludges and pastes is also likely. The inerted atmosphere placed over the feed preparation operation is necessary to avoid pyrophoric reaction, but has the drawback of requiring workers to enter an IDLH (immediately dangerous to life and health) environment on supplied air to service equipment and for final equipment decontamination. Although workable, alternatives that do not present this situation must be seriously considered.

Manual decontamination of drums, drum debris (present in B-12 containers), waste boxes, and feed preparation and treatment units also provides opportunities for worker exposure. Also, the inability to adequately decontaminate feed preparation and treatment equipment for free release as a result of hard to reach surfaces would significantly add to the overall cost of the project.

The need for the aggressive feed preparation effort proposed by GTS Duratek must be examined with respect to steam reforming technology. Entire drums of waste have been successfully treated in steam reformers without the need to prepare the wastes (Synthetica, 1989). The obvious benefit is minimal materials handling and worker exposure (DOE, 1998). This approach depends on the ability of superheated steam at 1110°F to sufficiently penetrate the solid waste matrix and will, in large part, depend on the physical nature of the waste. To be certain, treatability studies must be performed for each waste stream. The need for treatability testing is acknowledged by GTS Duratek in their response to the CBD advertisement. In addition to the uncertainties associated with effective steam penetration in the dense DU solids and sludges, sludge-liquid contact in the SET unit must also be examined prior to implementation of this treatment alternative. The treatability effort would have to consider the physical variability in the waste stream. For example, a series of steam penetration tests must be examined to determine the effectiveness of the technology on oily sludges, pastes, and densely compacted solids. Treatability tests must also be performed to support the stabilization operation. Specifically, testing must determine the appropriate "recipe" and waste loading for the effective stabilization of cadmium.

This evaluation concludes with mention of several operational hazards associated with the GTS Duratek treatment process. These include operation at high temperatures as well as the generation of flammable (i.e., hydrogen and methane) and acid (i.e., HCl) gasses in the steam reformer. The latter is extremely corrosive at the operating temperatures in question and can result in stress of system components. Volatility of uranium metal will not be an issue once the oxide is formed although radionuclide-contaminated particulate carryover from the evaporator unit to the reactor is of concern (DOE, 1998). The latter depends on the physical nature of the feedstock wastes and how they are physically affected by superheated steam. Hazards associated with SET unit include pressurized operation and mechanical movement.

B.2 Materials & Energy Corporation (M&EC)

Process Description. M&EC suggests that the radioactive metal and contaminated soil wastes be treated by solvent washing and vacuum-enhanced thermal desorption (TD), as illustrated by the flowsheet presented in Figure 2. The flowsheet shows that after the mineral oil is drained from each drum, radioactive metal and contaminated soil wastes are hand-sorted to remove large pieces and metal for special handling. Larger pieces are fed to an auger for size reduction and the remaining material is staged into the appropriate treatment volumes for processing. Per the flowsheet, the radioactive metal waste is first treated by solvent washing and then by TD to reduce the chlorinated solvents and PCBs to below treatment goals. Following treatment in the TD unit, the waste is solidified to remove the pyrophoric and toxic characteristics. Alternatively, feedstock soil is fed directly to the TD unit to desorb chlorinated solvents and PCBs to below treatment goals.

Waste liquids and sludge recovered during oil draining, solvent washing, and TD operations are treated by direct chemical oxidation (DCO), and the waste from the DCO unit is stabilized for land disposal. Containers are decontaminated with a non-hazardous solvent. The spent solvent is recycled to the solvent washing unit.

The solvent washing unit mixes a non-hazardous solvent with the radioactive metal waste, such that thorough and intimate contact is achieved, extracting the organic contaminants of concern into the solvent. The radioactive metal waste is allowed to settle prior to draining the solvent from the mixing tank, and the spent solvent is reclaimed by distillation using a batch still. This minimizes the quantity of the spent solvent requiring treatment for disposal. The wet radioactive metal waste is transferred to the TD unit for further treatment of the organic contaminants.

The TD system proposed is a batch unit that employs radiant heat and a sweep gas (i.e., air or inert gas) to volatilize organic contaminants from the wastes into the sweep gas. A high vacuum is applied to the desorber to enhance the volatilization of higher boiling point contaminants such as PCBs. The contaminant-carrying sweep gas from the desorber is filtered to remove particulates, chilled to recover organic constituents, and polished with activated carbon prior to atmospheric discharge.

Process Evaluation. The primary advantages of solvent washing are its simplicity, room temperature operation, and relatively high contaminant removal efficiencies for certain types of wastes such as granular solids and sands containing organic surface contamination. Solvent washing can also be very effective as a pretreatment step for significantly contaminated waste where removal of a major portion of the organic contaminants enables the overall treatment process to attain final treatment goals. Also, the solvents typically employed are non-hazardous and may be recovered and reused.

The effectiveness of solvent washing the Trench 1 oily sludges and pastes is uncertain, however. Particle size and porosity of the waste solids as well as any surface coatings and channeling may limit the solid-liquid contact achieved in the unit. The treatment approach suggested by M&EC addresses the need for solid-reagent contact (as well as solid-gas sweep contact in the TD unit) by sorting and size reducing the wastes prior to treatment. These feedstock preparation activities, which need to be performed in an inert atmosphere, should enhance the overall waste-reagent contact achieved in both the solvent washer and the TD unit. However, as discussed in Section 4.1 for the GTS Duratek process, size reduction and feed segregation of the Trench 1 wastes have several important disadvantages including worker exposure, equipment shutdown, and equipment decontamination. Entrainment of solids during solid-liquid separation, safety hazards associated with using solvents with pyrophoric material, and the generation of secondary waste streams (i.e., spent solvent and filter media) pose operational challenges with this technology.

The suggested process will experience difficulty in processing the radioactive metal and soil wastes contained in the B-12 boxes. If this material is processed in the solvent washer, a significant quantity of solid entrainment may be observed in the spent solvent which will cause problems in distillation and add to material handling problems of the secondary waste streams. Alternatively, the radioactive metal waste and soil could be manually segregated, with the metal waste going to solvent washer and the soil to TD unit. However, this will only increase worker exposure and it is suspected that the separation would not be complete enough to avoid the aforementioned problems associated with solids carryover.

There is an abundance of data demonstrating the performance of TD technology for removing chlorinated solvents. In fact, the TD unit proposed by M&EC has been successfully used three times at RFETS for desorbing TCE and PCE from soils (i.e., Ryan's Pit, Mound Site, and the Trench T-3/T-4 projects). TD technology has also been shown to be effective in the removal of heavier organic contaminants such as PCBs (i.e., less than 2 ppm) when high vacuums are applied (Mclaren Hart, 1998).

The pyrophoric nature of DU and the presence of PCBs in the wastes necessitates the use of an inert gas sweep. The presence of oxygen and PCBs at elevated temperatures may potentially result in the formation of dioxin and furan compounds. Treatability testing must be conducted to ensure that such reactions do not occur. Also, oils not removed in the solvent washer are susceptible to smoking, where the nature of the radiant heat source can lead to high localized waste temperatures and subsequent cracking of any oils present.

B.3 Geosafe Corporation

Process Description. Geosafe Corporation proposes that the Trench 1 radioactive metal and soil wastes be treated in a batch vitrification unit. The primary components of the unit are illustrated in Figure 3 and include a waste treatment cell, an offgas collection hood, and an offgas treatment system. The treatment cell is constructed of reinforced concrete and is typically poured below ground surface much like a residential foundation. The bottom of the cell is "lined" with approximately three feet of compacted, clean soil. Drums and waste boxes containing the radioactive metal and soil wastes are placed on the soil liner in the center of the treatment cell. Mineral oil is drained from the drums prior to placing the drums into the cell. Contaminated soil from B-88 waste boxes or clean soil is then used to fill the void spaces inside and between the containers. Clean soil is then placed around and over the top of the drums and compacted with a backhoe or excavator. The clean soil buffer extends to the walls of the treatment cell.

After the treatment cell is loaded and compacted, an electrically-conductive graphite material is placed on top of the soil which provides the initial conductive pathway for the electric current that is necessary to begin the melt. The offgas collection hood is then placed over the cell and an array of four electrodes is inserted through the hood to the soil surface and graphite starter material. With the offgas treatment system is in place, electrical energy is applied to the starter material through the electrodes. The electrical energy is converted to thermal energy as it encounters resistance while traveling through the graphite. The heat released melts the graphite and adjacent soils. Once the melt is formed, it serves as the conductive pathway and heat source for the melt to grow. Soils and wastes adjacent to the melt are heated by conduction and subsequently melt when they reach the appropriate temperature. As the melt proceeds, the electrode array travels downward by gravity, delivering electrical energy throughout the volume of the melt. The power required to carry out the melt typically ranges from one to four megawatts depending on soil and waste type, waste loading, cell size, and desired processing time. The electrical energy is provided by a 13.8 kV supply line. The temperature of the melt typically ranges from 1,600 to 2,000°C.

The temperatures achieved in the melt serve to pyrolize organic contaminants and debris present in the soils and wastes to simple gases (e.g., carbon dioxide, carbon monoxide, simple hydrocarbons, water vapor, and hydrochloric acid). The offgas leaving the collection hood is filtered, quenched, scrubbed and polished with activated carbon prior to atmospheric discharge. Inorganic contaminants are oxidized and are chemically incorporated in the melt. After all wastes are melted, as indicated by the electrodes reaching the soil liner, the power is de-energized and the melt allowed to cool and solidify (several days). The resulting glass-like product is chipped out of the treatment cell and containerized for subsequent disposal. The treatment cell is charged with the next batch and the process repeated.

Process Evaluation. The batch vitrification process proposed by Geosafe has several important advantages with respect to the treatment of Trench 1 radioactive metal and soil wastes. First and foremost is the minimal amount of feed preparation and worker handling that is required. The process does not require that wastes be removed from their containers. The steel drums and waste boxes are melted along with the wastes in the treatment cell. Feed preparation consists of draining the mineral oil from the overpack drums, removing overpack drums and inner drum lids, filling void spaces within the primary containers with soil, and compacting the containerized material. The drums and boxes are also pierced to provide additional pathways for the vapors that are generated inside the containers to escape. The compacting and piercing activities are performed in the treatment cell with the aid of heavy equipment. In the event that pyrophoric activity is observed while preparing the batch charge, clean soil can be used to smother the reaction as was done during excavation. The residual mineral oil remaining on the solids should reduce the potential for pyrophoric activity relative to what was encountered during excavation.

Batch vitrification of the wastes takes place without the need for mechanical movement of feedstock wastes, reagents, or product (e.g., feed delivery, waste-reagent mixing, etc.). The absence of moving parts greatly reduces the likelihood of a process shutdown, and thus, the need for operators to work on contaminated equipment during restart efforts. The blowers and pumps associated with the offgas treatment system are not immune to operating problems, however. Because these components are located downstream of the treatment cell, working on them should afford minimal exposure to contamination.

Other than the heavy equipment and associated compacting and piercing attachments, there is no equipment that comes in direct contact with the waste that would otherwise require decontamination at the conclusion of the project. While processing the last batch of waste, the melt is allowed to proceed through the soil liner and the bottom of the concrete treatment cell. As long as the clean soil buffer between the treatment area and the cell walls is maintained throughout the project, unmelted soil and the cell walls should not be contaminated. The cell walls can be broken and disposed as clean rubble or used as structural fill material.

As is the case with steam reforming and SET, vitrification has the benefit of eliminating regulated organic contaminants in one step. In addition, vitrification also has the benefit of stabilizing radionuclides and hazardous metals in this same step. The need to transfer the wastes to a cementation unit, for example, is eliminated. Stabilization is achieved by chemically incorporating the metals into the glass product. In order for a metal to be chemically incorporated into the glass matrix, it must be in the form of an oxide so that it is "compatible" with the chemistry of the melt (i.e., silicon and aluminum oxides). Fortunately, the thermodynamics at melt temperatures favors the formation of uranium oxide over the iron oxides present in the soils. Thus, the metallic uranium present in Trench 1 wastes will preferentially oxidize while the iron oxides present in the soil and wastes (e.g., corroded drums) are reduced to metallic iron. Once oxidized, the uranium is chemically incorporated into the melt and final glass product in the same manner that lead oxide is incorporated into glass crystal. Retention of radionuclides and hazardous metals in the melt may be adversely effected if the soils and wastes placed in the treatment cell do not possess a sufficient iron oxide content to ensure complete oxidation of all metallic uranium present in the wastes. In such cases, ferrous oxide can be mixed in with the native soils to ensure a stoichiometric excess of mineralized oxygen.

Bench-scale vitrification data indicate that as much as 99.99% of the uranium present in the feedstock wastes is retained in the final glass product (Hansen, 1991). Similar studies have indicated retention efficiencies as high as 99.99% for thorium as well (Hansen, 1991). Unfortunately, bench- and pilot-scale vitrification studies suggest only a 67 to 75% retention efficiency for cadmium, a semi-volatile metal. Volatilization of cadmium from the melt to the offgas is the biggest drawback of using batch vitrification for the treatment of Trench 1 radioactive metal and soil wastes. There are several measures that may be taken to achieve the highest possible retention of cadmium in the melt. First, a "extra thick" clean soil layer may be placed over the top of the wastes which will create a thick contaminant-free layer of molten material through which elemental cadmium will have to travel in order to volatilize to the offgas stream. The higher residence time in the melt increases the probability that cadmium will be converted to a non-volatile oxide and remain in the melt. A thick melt layer above the wastes will also serve to maximize the degree of organic contaminant pyrolysis achieved prior to volatilization from the surface of the melt. Second, the offgas scrubbing unit should be designed to maximize cadmium removal. Finally, the temperature of the melt should be maintained at the lower end of the vitrification temperature range to minimize the driving force for cadmium volatilization. Vapor bubbles generated within the melt from the volatilization and pyrolysis of residual mineral oil and organic compounds will offset these measures, however. Vapors traveling upward through the melt will serve to transfer contaminated melt upward as well, effectively reducing the volume of melt that a contaminant must first migrate through prior to volatilizing to the offgas.

Another disadvantage commonly cited when considering vitrification for the treatment of hazardous and mixed wastes is the potential for pressurization of void spaces that may exist in the wastes matrix. Hot gases generated by the melt can accumulate in void spaces. If the space is large enough and sufficiently confined, violent release of accumulated vapor can occur in the melt. This phenomenon is of particular concern when attempting in place vitrification of buried wastes (i.e. *in situ*). In this case, it is difficult to know where void spaces may exist in the subsurface or within buried containers. In contrast, there is much more control and certainty in *ex situ* applications of this technology. As described above, excavated wastes are placed into a treatment cell in a controlled manner. Waste containers are opened and any void spaces present are filled with soil. The fill is compacted and the containers are pierced to provide vapor release pathways in addition to open top of the container. The latter measure is especially important considering that the melt progresses from the top to the bottom of the treatment cell.

Another drawback of batch vitrification is the generation of waste streams such as spent filter media, scrubber solution, and activated carbon. The technology does provide for the recycle of much of the secondary waste generated during a project to be recycled to the treatment unit. Unfortunately, this is not an option for the secondary wastes that are generated during the last batch processed.

The vitrified glass product is a superior waste form and is well suited for land disposal. Because the uranium, thorium, and cadmium are chemically incorporated into the product, leachability of these inorganic contaminants is essentially nonexistent as determined by TCLP analysis (Hansen, 1991). The glass product is also structurally sound and is reported to be approximately ten times stronger than unreinforced concrete.

From an implementation standpoint, the offgas collection and treatment equipment is readily available and transportable. The treatment cell is specifically designed and constructed for the application at hand. Treatability testing is necessary to support the design of the cell and preparation of the batch charges. Treatability testing allows determination of the proper waste loading and the necessity of introducing conductive and oxide additives to the native soils.

As noted above, the process requires one to four megawatts of power. Discussions with RFETS Engineering and Plant Power personnel indicate that the 13.8 kV overhead line at the Trench 1 project site is capable of supplying the required power.

B.4 Allied Technology Group (ATG)

Process Description. ATG proposes that the Trench 1 radioactive metal and soil wastes be treated in a continuous vitrification unit. As illustrated in Figure 4, electric power is delivered to the treatment unit in two forms. The first is an alternating current, similar to that employed in the Geosafe batch vitrification process, that is applied to the melt at the bottom of the unit. As described above, this electrical energy is converted to heat as resistance to the current flow is encountered in the melt. A second source of power, a high energy direct current, is applied in the vapor space directly over the surface of the melt. Unlike the flow of current through the conductive melt, the direct current energy arcs across the non-conducting air space, and in the process, creates an extremely high temperature plasma (approximately 12,000°C). Radiant heat from the plasma also provides thermal input to the melt.

In practice, waste is continuously fed into the treatment chamber with an auger. The feed is directed through the plasma and into the melt. Pyrolysis of organic contaminants occurs in both the melt and the plasma arc. The elevated temperatures of the plasma ensure that the pyrolytic reactions are taken to completion to form carbon dioxide and hydrogen. The offgas from the plasma arc unit is treated prior to atmospheric discharge in a similar manner as described earlier for the batch vitrification process.

Under steady state operating conditions, the melt continuously exits the treatment unit through an overflow weir. The molten flow is directed into waste containers where it is allowed to cool and solidify. Metallic iron from the waste containers and the reduction of iron oxides in the feed soil (see Section 4.3) is similarly removed as it accumulates at the bottom of the treatment unit.

Process Evaluation. Many of the same assessments made in Section 4.3 for batch vitrification technology also apply to ATG's continuous plasma arc vitrification process. Both technologies offer the benefit of organic contaminant destruction and inorganic contaminant immobilization in one processing step. The feed must be properly prepared for both processes to achieve the proper waste loading, melt conductivity, and ferrous iron content. Both technologies produce the same superior waste form that is well-suited for land disposal. Finally, treatability studies are required in each case to obtain waste-specific performance data that allow the processes to be tailored to the waste treatment application. With these commonalities in mind, the remainder of this evaluation focuses on the important differences between ATG's continuous vitrification process and Geosafe's batch vitrification unit with respect to the treatment of Trench 1 wastes.

The degree of materials handling necessary to prepare the wastes for treatment constitutes an important difference between ATG's plasma arc process and Geosafe's batch vitrification unit. The continuous feed and processing requirements of the plasma arc process necessitates size reduction and blending of the wastes to ensure a successful operation. Such activities raise concerns of worker exposure and equipment downtime as discussed in other sections of this report regarding the technologies proposed by GTS Duratek, M&EC, and Perma-Fix. The ability to decontaminate the feed preparation equipment and feed auger for free release at the conclusion of the project is also uncertain.

Continuous processing does offer the opportunity for higher overall waste processing rates if the equipment can be kept operating. Specifically, production time is not lost while waiting for batches of vitrified waste to cool and solidify (days) and for the contents of a batch treatment cell to be manually broken apart and removed. The advantage of increased throughput achieved by continuous processing is not significant for the Trench 1 project, however, considering the relatively small volume of wastes that require treatment. In contrast, the risks associated with auger jamming and flow blockage are far more important.

Another critical disadvantage of the plasma arc process relative to batch vitrification is the potentially higher volatilization of cadmium (as well as uranium and thorium) resulting from the 12,000°C plasma. Treatability study data are required to evaluate this issue. Volatilization of cadmium may be further promoted by the relatively small volume of vitreous melt present in the plasma arc treatment unit. The smaller volume of melt may afford less opportunity for cadmium to oxidize which could lead to lower the surface of the melt will be condensed and converted to a non-volatile oxide. Of course, the duration that contaminated wastes are maintained at melt temperatures is, on average, shorter in a continuous process than in a batch process. It should also be noted that the high temperatures present in the plasma arc will pyrolize organic contaminants more completely than in the batch process. This advantage is somewhat offset, however, by the ability to recycle secondary wastes in the batch vitrification unit.

B.5 Perma-Fix Environmental Services

As with M&EC, Perma-Fix suggests that solvent washing and TD technologies be used to remove organic contaminants from the Trench 1 radioactive metal and soil wastes (Figure 5). Likewise, cementation is proposed to solidify wastes prior to disposal. Description and evaluation of these technologies for the treatment of Trench 1 wastes need not be repeated. The reader is referred to the discussion and analysis presented in Section 4.2.

B.6 Starmet Corporation

The Starmet proposal includes a treatment strategy that is based on the incorrect position that individual containers of Trench 1 wastes can be "segregated" from a waste classification standpoint. The proposal assumes, for example, that a drum of DU waste can be considered nonhazardous if the one sample analysis for that drum was found to contain RCRA
and TSCA contaminant concentrations less than land disposal restrictions. This is, of course, in contrast to the RCRA- and TSCA-regulated determinations presented in Section 2 which apply to the entire waste stream. With this said, the only regulatory-permissible alternative proposed by Starmet is a combination of onsite treatment with SET to eliminate chlorinated organic contaminants (see Section 4.1), followed by offsite treatment at a RCRA-permitted facility (i.e., Perma-Fix) to stabilize the wastes. The disadvantages and uncertainties associated with the use of SET for the treatment of Trench 1 wastes are discussed in Section 4.1. Moreover, the combination of onsite and offsite treatment is not economical and unnecessarily generates additional wastes. It makes far more sense to continue treatment through to its logical end once it is started as opposed to repacking SET-treated DU wastes with fresh mineral oil and shipping to an offsite location to complete treatment.

B.7 Comparative Analysis

The evaluations presented above suggest that two technologies, steam reforming and batch vitrification, have the most potential for the onsite treatment of the Trench 1 radioactive metal and soil wastes. The distinguishing benefits of these technologies include minimal feed preparation and worker exposure and the destruction of organic contaminants in one processing step. Batch vitrification has the added advantage of immobilizing the inorganic contaminants into a superior waste form in this same processing step. There are uncertainties associated with the application of each of these treatment technologies to the Trench 1 wastes. In the case of steam reforming, for example, there is uncertainty regarding the ability of the steam to effectively penetrate the various solid waste forms without first size reducing and segregating the feedstock. Uncertainties regarding batch vitrification include hazards associated with void spaces present in the wastes, vaporization of semi-volatile metals, and formation of dioxin and furan compounds resulting from the partial oxidation of PCBs in the feedstock. Nonetheless, the evaluations suggest that immediate implementation of onsite treatment would best be pursued with the Geosafe batch vitrification process. The technical and operational issues associated with batch vitrification appear to be manageable resulting from the partial oxidation of PCBs in the feedstock. Nonetheless, the evaluations suggest that immediate implementation of onsite treatment would best be pursued with the Geosafe batch vitrification process. The technical and operational issues associated with batch vitrification appear to be manageable through the design of the feed batch charge. Onsite implementation of batch vitrification is therefore examined below in more detail.

From an implementation standpoint, Geosafe Corporation appears to have a fair amount of operating experience with vitrification technology. The company has completed 85 large-scale melts comprised of approximately 22,000 tons of waste since 1993. These melts consist primarily of test demonstrations, but several full-scale remediation projects account for the balance. The latter includes the *in situ* and staged batch vitrification of hazardous wastes present at three EPA Superfund sites. Also, the company is currently involved in the *in situ* vitrification of 21 burial pits contaminated with plutonium and uranium at the Marlinga site in Australia. Treatment operations began at this site in May 1998, and since that time, 12 of the anticipated 26 melts have been completed. Geosafe also has experience working at the following DOE sites conducting bench-, pilot-, and demonstration-scale work:

Hanford	Large-Scale Demonstration	1989, 1990
INEL	Pilot-Scale Test	1987, 1990
Oak Ridge	Pilot-Scale Test	1987, 1991
Savannah River	Bench-Scale Test	1993
Brookhaven	Bench-Scale Test	1996
Oak Ridge	Large-Scale Demonstration	1996
INEL	Bench-Scale Test	1998

In addition, the company will begin a test demonstration at LANL in February 1999. The demonstration will involve two *in situ* large-scale test melts, the first in a "cold" area and the second in a "hot" area. The hot area is contaminated with several radionuclides including plutonium, uranium, americium, and cesium.

Final assessment of onsite batch vitrification for the treatment of Trench 1 wastes requires detailed evaluation of the process data generated by vitrification projects conducted to date. Analysis must focus on the physical and chemical nature of feed wastes processed, design of the batch charge, offgas analytical data, the necessity and required scope of treatability work, and operational and cost considerations. Additional analysis must also consider the costs associated with all RFETS-specific requirements that may apply to a vitrification operation (e.g., the need to conduct an environmental impact statement). Nonetheless, a budgetary cost estimate for the onsite batch vitrification of Trench 1 radioactive metal and soil wastes has been prepared and is presented in Table B-1. The estimated cost of approximately two million dollars includes the preparation of project control documents (e.g., PAM, HASP, SAP, etc.), treatability testing, extensive analytical work, as well as contingency funds for unanticipated costs.

The schedule for planning and executing a batch vitrification project at RFETS is anticipated to be similar to that experienced for the thermal desorption treatment of Trench T-3/T-4 soils. The significantly smaller volume of wastes in the Trench 1 project will be offset by the unfamiliarity of the vitrification process to personnel at RFETS and the potential need to conduct a treatability test. Overall, a batch vitrification project, from planning to treatment to closure report preparation is expected to take approximately 15 to 18 months (see Table B-2).